Projecting warming's impact on Bay Area

James Temple
Updated 11:02 pm, Saturday, January 5, 2013

It's now indisputable that the Earth is warming, at least for anyone who still takes thermometers at their word.

Average global temperatures have ticked up by about 0.8 degrees Celsius since 1880, and two-thirds of that increase has taken place since 1975, according to the National Aeronautics and Space Administration. Nine of the 10 warmest years in that time period have occurred since the year 2000.

To be sure, the planet has experienced cooling and warming periods in the past. But the steep temperature rise in the late 20th century blew past the highs of the last 1,000 years, the period for which there are reliable data.

And more warming is on the way. A variety of studies have concluded that current rates of fossil fuel emissions could push global temperatures up by as much as 6 degrees Celsius by 2100. To put that in context: A 2007 report by the U.N. Intergovernmental Panel on Climate Change predicts that an increase of just 3.5 degrees would drive into extinction 40 to 70 percent of the species for which the impact of global warming has been studied.

There is an overwhelming scientific consensus that fossil fuels are primarily to blame for the warming in recent decades. Nearly 98 percent of climate scientists actively publishing agree with that conclusion, according to a 2010 study by researchers at Stanford.

That study also found that the few researchers still unconvinced of what's known as anthropogenic climate change published far less on average in peer-reviewed climate literature, the accepted mark of scientific expertise and prominence.

Wildfires and floods

The consequences of a warming world are already making themselves known.

It's difficult to link any single season or weather event to climate change, but 2012 was a veritable case study in the patterns scientists have long warned could become the new normal. By midsummer, U.S. temperatures broke more than 40,000 daily heat records, and 2012 was almost certainly the warmest year on record. (The National Oceanic and Atmospheric Administration will report official December temperatures later this week.)

The resulting drought affected 80 percent of U.S. agricultural land, and the hot, dry conditions set the stage for one of the worst wildfire seasons in recent memory across the West.

In October, Superstorm Sandy, the largest Atlantic hurricane ever recorded, devastated the Eastern Seaboard, killing more than 100, knocking out power for millions and exacting an economic toll of more than $60 billion.

Munich Re, a global reinsurance company, released a study that same month underscoring a sharp increase in "weather-related loss events" over the past three decades. Nowhere was that more true than in the United States, where costly catastrophes like thunderstorms, tornadoes, wildfires, droughts and floods have nearly quintupled during that time.

Terra incognita

Without drastic changes to fossil fuel emissions, the impacts of global warming will land on the Bay Area with a brute force that pays no regard to our relatively liberal politics, farsighted state climate regulations or fondness for hybrid vehicles.

By 2050, rising sea levels could put land around the bay equivalent in area to six San Franciscos at risk of serious flooding, including the region's airports, a stretch of Silicon Valley high-tech campuses and the homes of more than 100,000 residents, according to the San Francisco Bay Conservation and Development Commission. Sea levels could surge nearly 6 feet by 2100, putting more than $60 billion in shoreline development in jeopardy.

The rising tides will also magnify the region's existing vulnerabilities to tsunamis and earthquakes, researchers say.

As California's temperatures climb, the Sierra snowpack that stores about a third of the state's water will dwindle. The increasing heat could also undermine the fog that feeds coastal ecosystems, including Northern California's treasured redwoods.

Land with the unique terroir necessary for the region's renowned grapes will shrink, devastating the wine and tourism sectors alike. Wild plant and animal species will migrate up hillsides and into different bodies of water, altering sensitive ecologies in complicated and unpredictable ways.

"It's terra incognita," said Jane Long, a former associate director at Lawrence Livermore National Laboratory and a visiting scientist at UC Berkeley. "We don't know where we're going, but we know we're heading toward something that could be very, very dangerous."

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Cloud brightening: theory to prototype

James Temple
Updated 11:01 pm, Saturday, January 5, 2013

T he godfather of cloud brightening is John Latham, a British cloud physicist who first proposed the idea in 1990.

He calculates that increasing the average reflectivity of maritime clouds from about 50 to 60 percent would be enough to offset the warming produced by a doubling of carbon dioxide concentrations in the atmosphere, a finding supported by other scientists.

But that would require cloud brightening efforts along large portions of the west coasts of the Americas and Africa, an area stretching tens of thousands of miles.

Cloud formation depends on what are known as cloud condensation nuclei, tiny particles like dust that provide a surface on which water can make the leap from a vapor to a liquid.

The belief is that spraying a fine mist of salt water toward coastal clouds will provide additional salt particles for water droplets to condense around. That could increase the concentration of droplets, thus making the clouds more reflective.

A fleet of 1,500 ships

The basic proposal is to send out ships equipped with special machinery that could continually suck salt water from the ocean and spray it toward the clouds from the top of towers roughly 100 feet high. Natural updrafts could carry the particles the rest of the way.

Stephen Salter, a British scientist working on the nuts and bolts of cloud brightening, advocates using a fleet of remote-controlled vessels powered by so-called Flettner rotors, highly efficient sails fueled by the wind. He estimates that 1,500 ships might do the trick, at a cost of about $2.5 billion on the low end.

Bay Area researcher Armand Neukermans, who is overseeing a team of engineers working to develop a cloud-brightening prototype, said that cargo vessels already sailing those waters could be equipped for the task, perhaps with the nudge of carbon credits for their owners.

The chief technical problem is that the technology doesn't yet exist to release both the vast quantity and very particular size of salt particles necessary for any of this to work on a large scale.

'Micro-nozzles'

Salter estimates that 0.8 microns is the ideal particle size. To put that in perspective, a human hair measures about 70 microns across.

Salter has developed "micro-nozzles," silicon wafers about 8 inches around perforated with about 1.5 billion tiny holes, through which the salt water can be pumped, wrote author Jeff Goodell in "How to Cool the Planet."

Neukermans' team spent years on a similar approach, but ran into several problems.

Spraying vast amounts of water cools the air significantly, which makes it harder for the particles to get sucked up into the clouds. The other issue is that micro-nozzles clog easily.

The Sunnyvale team has since taken a different path, using heat and pressure to convert the water into a supercritical state, a kind of limbo between a liquid and a gas. They've found the particles come out of the nozzles the right size and that they can get the same quantity into the sky using much less water.

This process requires more energy, but they believe it can be fueled from the waste energy given off by typical ship engines.

The remaining technical hurdle is that the nozzles still eventually clog and corrode, a challenge Neukermans and his colleagues are attempting to solve by applying different materials, such as coating the insides of the nozzles with gold.

"He's made a lot of progress," Latham said. "His results are very promising."

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Turning over new leaf in climate change

James Temple
Updated 11:29 pm, Saturday, January 12, 2013

In a tidy white lab on the southern edge of Berkeley, scientists are trying to duplicate one of nature's greatest tricks, pulling energy out of thin air.

They're designing artificial leaves that can convert sunlight, carbon dioxide and water into chemical fuel, much like the photosynthesis of flowers and trees.

The team has already built a crude prototype from silicon, polymers and platinum that can create a simple and clean hydrogen fuel. If the scientists figure out how to cheaply produce more complicated energy sources, it would enable mass production of "drop-in" fuels that could power automobiles, trucks, planes and ships without pumping more greenhouse gas into the atmosphere.

In other words, it could provide a viable alternative to digging up more petroleum, coal and other traditional energy sources widely blamed for global warming.

"We have no other option than getting off fossil fuels," said Heinz Frei, acting director of the lab, the north site of the Joint Center for Artificial Photosynthesis. "The research into artificial photosynthesis provides society with an option."

That simple, that hard

Without drastic changes to global energy systems, studies show that rising fossil fuel emissions could push global temperatures up as much as 3 degrees Celsius by 2050 and 6 degrees Celsius by 2100, unleashing a series of dangerous ecological consequences.

Researchers are investigating an array of possibilities for preventing or offsetting certain effects of a warming world, from sucking carbon out of the atmosphere to increasing the reflectivity of clouds. But even those exploring such options say the only way to address the full scale of global warming is to attack the root cause: cutting greenhouse gas emissions as much and as quickly as possible.

"The energy sources we use can't be fossil fuels," said Jane Long, former associate director for energy and environment at Lawrence Livermore National Laboratory. "It's just that simple and just that hard."

Venture capitalists, startups, corporations, government researchers and academic labs around the region are working aggressively to develop or deploy more efficient renewable energy sources, including next-generation batteries, electric cars, light bulbs, biofuels, hydroelectricity, and geothermal and wind power.

Tapping sunlight

But among clean energy options, tapping into the direct power of sunlight is uniquely promising. The sun casts more energy on the globe in one hour than all of humankind consumes in a year. The problem is that existing technology doesn't efficiently capture and store those diffuse and intermittent beams.

That's where artificial photosynthesis comes in.

It could retain more of the sun's energy than biofuels, which for a variety of reasons store well below 1 percent of the energy in the sunlight that touches them. And unlike solar panels, the energy produced by artificial photosynthesis would be highly portable, packed into a dense fuel that could power vehicles over long distances.

"There are lots of ways to provide electricity to things that don't need to take their energy source with them," said Graham Fleming, vice chancellor for research at UC Berkeley and a chemistry professor who has done groundbreaking research in photosynthesis. "But planes, ships, cars and trucks are a different problem and one we don't have a good solution for."

And it's a big problem. Transportation contributes more than a quarter of total U.S. greenhouse gas emissions, and accounted for nearly half of the net increase during the past two decades, according to the Environmental Protection Agency.

The real challenge

During a tour of the Berkeley lab last month, Frei, a slight Swiss chemist with a head of gray hair, stopped at a work space and picked up the closest thing his team has to an artificial leaf.

The "engineering model" looks nothing like its natural counterpart. Four tilted purple strips fill the translucent box, which fits in the palm of his hand.

It would take a microscope to see that these thin strips are, in fact, tiny fibers made from silicon-based material. They absorb light to power a series of chemical reactions.

Iridium oxide catalysts attached to the tops of the strips split water into oxygen and protons. A membrane in the middle holds back the oxygen, but allows the protons to pass through. Finally, platinum catalysts on the other side of the strips convert the protons to hydrogen (H_2), a simple energy carrier.

A convergence of technological and scientific advances has propelled the research to this point. Big strides in computer speeds and software capabilities have accelerated the ability to identify ideal materials. The birth of nanotechnology has allowed scientists to work at the necessary scale of atoms and molecules. And earlier work by Frei and others has enabled humans to capture energy from a larger portion of the sunlight spectrum (see related story).

But there's a major obstacle remaining: The device that Frei displayed isn't anywhere near economical. The components are too expensive and fragile, and the resulting fuel too inefficient.

"That's the real challenge JCAP is trying to take on - not how to do it, but how to do it with cheap, abundant materials," UC's Fleming said.

The other trick is to adapt the process to produce fuels with higher energy density, closer in kind to gasoline, yet renewable.

Such fuels would emit carbon dioxide. But since they would be made from the carbon dioxide already in the air, rather than extracted from the ground, the fuels would be carbon neutral - potentially providing a way to halt the rise of fossil fuel emissions.

The approach was promising enough to catch the eye of the federal government.

Joint project born

In late 2009, the U.S. Department of Energy announced plans to invest $122 million over five years into three "high risk, high reward" energy research projects, including an effort to produce fuel directly from sunlight. The goal was to drive scientific breakthroughs in promising research areas too costly or unproven for the energy industry to take on itself.

"Given the urgency of our challenges in both energy and climate, we need to do everything we can to mobilize our nation's scientific and technological talent to accelerate the pace of innovation," Energy Secretary Steven Chu said at the time.

The proposal from the California Institute of Technology, in partnership with Lawrence Berkeley National Laboratory and other organizations, clinched the prize. The Joint Center for Artificial Photosynthesis, or JCAP, was born in 2010, with offices in Pasadena and Berkeley.

Nathan Lewis, a chemistry professor at Caltech, serves as the organization's overall director. The cross-disciplinary team, on track to number nearly 200 researchers, includes synthetic chemists, material scientists, computational theorists, mechanical engineers and more.

Envisioning 'forests'

JCAP's researchers would leave the commercialization of the technology they are developing to others, but the ultimate idea is to cover millions of acres of land with artificial leaves. They probably would be made of a polymer-like material roughly an inch thick that could be rolled out like a blanket.

A key advantage over biofuels is that artificial leaves could be installed on nonarable land, reserving limited fertile acres for food production.

If man-made leaves covering 60 million acres converted just 1 percent of the energy in the sunlight that touches them into energy in the resulting fuel, Frei estimates they could produce all the energy now consumed by U.S. transportation. At 7 percent efficiency, they could produce all the energy used in the nation each year.

To be sure, 60 million acres is a lot of land, roughly the size of Oregon. But as Frei points out, there are more than 40 million acres of land devoted to the nation's interstate highways.

His analogy is a deliberate one. It's the space the country dedicated to an earlier national priority - transportation - that has contributed heavily to the problem at hand.

Another comparison: The nation leased more than 38 million acres of federal property to oil and gas companies at the end of fiscal year 2011, according to the latest data available from the Bureau of Land Management, and well above 60 million acres as recently as 1990.

"What it says is that society has already given away that kind of land, so it means it might be a socially acceptable level," Frei said.

High hurdles

Still, some observers doubt we'll see forests of artificial leaves anytime soon.

"I would not be surprised to learn that one day this will be done on a practical scale, at a reasonable cost," said Sally Benson, director of the Global Climate and Energy Project at Stanford University. "But we are very far from that point."

"When the needed scientific breakthroughs take place is anyone's guess," she said. "And once this occurs, if we can learn from experience in the energy sector, it will be decades before it grows to sufficient scale to displace the alternatives available today."

Opposition, expenses

Indeed, high hurdles have cluttered the path even to proven sustainable energy systems, including political opposition, climate-change denial, human inertia and enormous economic disincentives.

As environmental writer and activist Bill McKibben stressed in a recent Rolling Stone article, there are 2,795 gigatons of carbon in the proven coal, oil and gas reserves of fossil fuel companies. That's five times more than climate scientists say the world could burn with some hope of staying below a 2-degree-Celsius rise in average temperatures, the threshold widely viewed as a dangerous tipping point for the globe.

But research firm Capital Institute estimates those reserves are worth about $27 trillion. They're the primary asset justifying the multibillion-dollar market caps of energy giants. Those companies' stock prices reflect the clear assumption that these fossil fuels will be pulled out of the Earth, whatever the environmental cost.

A growing chorus of experts argues the only way to correct for this economic "externality" - a real cost that isn't accounted for in actual prices - is for government to step in with aggressive public policy, including incentives and penalties to move companies, researchers and citizens in the right direction.

"We need to leave that fossil fuel in the ground, and the only way that will happen is if they're honestly priced," James Hansen, head of NASA's Goddard Institute for Space Studies, said in an address at the Commonwealth Club in San Francisco last month. "Right now, they're heavily subsidized by you, the public."

But even if officials manage to enact effective policies, the world still faces a serious technical challenge. Studies show that the renewable energy options available to date can't get the world to a sustainable level of greenhouse gas emissions.

In fact, aggressively deploying existing technologies wouldn't be enough for California to reach its own legally mandated goal of making greenhouse gas emissions 80 percent lower than 1990 levels by 2050, according to a 2011 report by the California Council on Science and Technology. Achieving that aim will require "intensive and sustained investment in new technologies," the study concluded.

"You could get about halfway there," said Long, co-chair of the committee that produced the report. "The rest of the reduction will require innovation."

No other choice

That's why efforts like those under way at JCAP, specifically highlighted among possible "breakthrough technologies" in the study, are critical. No one knows yet what proposals ultimately will work. It's only clear that something has to.

For now, Frei and his colleagues are focused on achieving the goal they set when applying for the federal grant: building a working prototype that can produce fuel from the sun 10 times more efficiently than current crops. Year three of the Energy Department's five-year funding program just began.

Frei says he is confident they're on track and hopeful they'll secure additional money to continue refining the technology.

"We have to succeed," he said. "We have no other choice."

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Today: Creating artificial leaves for clean fuel.

Previously: Brightening the clouds to reflect away heat.

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Looking to sky to fight climate change

James Temple
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One afternoon last fall, Armand Neukermans, a tall engineer with a sweep of silver bangs, flipped on a noisy pump in the back corner of a Sunnyvale lab. Within moments, a fine mist emerged from a tiny nozzle, a haze of salt water under high pressure and heat.

It didn't look like much. But this seemingly simple vapor carries a lot of hope - and inspires a lot of fear. If Neukermans' team of researchers can fine-tune the mechanism to spray just the right size and quantity of salt particles into the sky, scientists might be able to make coastal clouds more reflective.

The hope is that by doing so, humankind could send more heat and light back into space, wielding clouds as shields against climate change.

The fear, at least the one cited most often, is that altering the atmosphere this way could also unleash dangerous side effects.

"Ten years ago, people would have said this is totally wacky," Neukermans said. "But it could give us some time if global warming really becomes catastrophic."

It's now beyond debate that the globe is getting hotter. The ice caps are melting, sea levels are rising, and extreme weather events like droughts, floods and hurricanes are increasing.

Even if public policymakers manage to significantly curtail future fossil-fuel emissions - the carbon dioxide and other greenhouse gases that the vast majority of climate scientists blame for climate change - the hundreds of gigatons we've already pumped into the atmosphere have probably locked in a series of life-altering consequences.

Neukermans and his colleagues are among an unofficial cadre of Bay Area scientists, technologists, designers and engineers who have begun the hard work of preparing for a warmer world. They're exploring unconventional concepts that might help us live with the consequences - or prevent them from spinning out of control.

It's not clear yet if any will work, or find the support to move off the drawing board. All are sure to be costly and controversial.

But much is at stake. Rising temperatures and sea levels threaten the region's homes, habitat, industries and infrastructure (see related story).

Balancing risk, reward

The concept of "cloud brightening" dates back 22 years, when British physicist John Latham first proposed it in a little-noticed paper in the journal Nature.

But as the threat of global warming rises, it and other "geoengineering" strategies have shifted from the scientific fringes into mainstream debate. Geoengineering is a broad category for techniques that could remove greenhouse gases from the atmosphere or reflect away more heat, including things as innocuous as painting roofs white and as controversial as spraying sulfate particles into the stratosphere.

The basic idea behind cloud brightening is to equip ships with mechanisms like the ones Neukermans' team is designing and aim them at the relatively low-lying clouds that hug the western coasts of continents. It would probably require hundreds - if not thousands - of vessels (see related story).

Few are eager to tweak a system as complicated, sensitive and interconnected as the climate. But many scientists worry that nations simply won't cut fossil-fuel emissions enough to prevent rising temperatures from unleashing humanitarian and ecological calamities.

"If we have to intervene, we should be doing the research now, because these ideas are extremely complicated and extremely risky," said Jane Long, a former associate director at Lawrence Livermore National Laboratory. "I hope we never have to do it, but I think it's irresponsible not to understand as much as we possibly can in case we need it."

Critics, however, argue that scientists are talking about tinkering with a system they don't fully understand. Altering the clouds could affect rainfall patterns, with potentially devastating consequences, they say.

"Large and small, these things all have other environmental effects and they're not solving the problem," said Kert Davies, research director at environmental group Greenpeace. He believes research efforts and dollars should be focused instead on clean-

energy technology.

"Geoengineering is like taking an aspirin for pain without addressing the disease," he said.

A pro bono project

Neukermans, a 72-year-old serial inventor from Belgium, agrees that the best response to climate change is to curtail greenhouse emissions.

Cloud brightening is "absolutely no replacement for the other things we should do," he said. "We should cut CO_2 as much and as fast as we can."

But that's simply not happening, even as predictions for rising temperatures this century soar past 2 degrees Celsius, the threshold that most climate scientists point to as the clear danger zone. So Neukermans and his team feel compelled to move ahead with their work.

Neukermans arrived in the United States in 1964. Over a four-decade career at General Electric, Hewlett-Packard, Xerox and elsewhere, he put his name on more than 75 patents. In 1997, he founded Xros, an optical switch company that pulled off the holy grail of telecom at the time: using tiny mirrors to move data through fiber network switches without converting them from pulses of light into electrical signals. In 2000, Nortel Networks acquired the company for $3.25 billion in stock.

Since retiring, Neukermans has dedicated his time and money to a series of social and environmental causes, including efforts to develop land-mine-detection technology and inexpensive prostheses for the poor.

He turned his attention to cloud brightening in early 2010, recruiting a team made up mostly of former colleagues, after the Bill Gates-supported Fund for Innovative Climate and Energy Research provided money for an initial viability test.

"He more or less showed it was feasible to my satisfaction," said Ken Caldeira, a prominent climate scientist at the Carnegie Institution on the Stanford campus and co-manager of the fund.

As the group attempts to develop an actual prototype, Neukermans is covering the expenses out of his own pocket - and the group is working pro bono.

The five-man team is an esteemed contingent of Silicon Valley's old guard. Most are in their 60s or 70s; they have playfully referred to themselves as the "Silver Linings."

But they're engineering heavyweights, boasting 250 years of experience and 130 patents among them. They include Lee Galbraith, inventor of a breakthrough tool for inspecting semiconductors, and Jack Foster, a laser pioneer who helped create the first checkout scanners.

Moving toward trials

It's clear that cloud brightening is possible. Satellites have observed "ship tracks," or whitened lines in marine clouds that large vessels have formed inadvertently by pumping out particles in their exhaust. Unknown is whether humans can do it purposely, on a large enough scale to matter, and without severely altering weather patterns elsewhere.

Scientists at the Met Office Hadley Centre in England ran computer simulations of wide-scale cloud brightening and saw sharp rainfall decreases in South America, with disastrous impacts on the Amazon rain forest.

Caldeira ran his own models for all ocean clouds and found that rainfall would decline over sea, but increase over land. More recently, physicist Latham, now at the National Center for Atmospheric Research in Boulder, Colo., put the Met Office's models to work and found the potential impact on the Amazon could be minimized by altering the location and amount of cloud brightening.

The conflicting results underscore some uncertainty about the overall consequences, in part because of the complexity of modeling the behavior of clouds. So as researchers get closer to working mechanisms for cloud brightening, it raises a critical question: What standards should apply before anyone tests such technology in the real world?

Last September, Latham and other scientists called for limited field trials once a nozzle technology is developed.

They were careful to stress that tests must be carefully planned to prevent any damage to the ecosystem, and said they should be conducted in an "open and objective manner" with consultations between international scientific organization and potential stakeholders.

Questions, concerns

But is preventing any fallout from such testing an achievable goal? And is it possible for all affected parties to reach consensus on these issues?

Wil Burns is dubious.

The director of the energy policy and climate program at Johns Hopkins University terms himself an "extreme skeptic" of cloud brightening. Even if it works, he's not convinced scientists will be able to easily identify or deal with any unintended consequences.

There's also the touchy question of social equity. Cloud brightening might cool global temperatures on average, but what if it leads to deforestation in South America or affects monsoon patterns in Asia? If the world is better off on average - particularly in the relatively temperate first world - is it acceptable that some nations suffer?

Such issues aside, Burns worries that politicians, energy companies and consumers will fail to perceive these tools the way scientists hope they will: as an option of last resort. Rather, he fears, they'll see them as an excuse to continue dumping waste into the atmosphere.

And even if geoengineering initially works, researchers might run into some disastrous side effect that only becomes clear over time, forcing them to cut off those efforts after a few years or decades.

"If you stopped, you'd get a massive carbon pulse and temperature increases as much as 10 to 30 times greater than if you'd continued climate change policy as it is," Burns said. "It would just be catastrophic."

Caldeira argues that the distant consequences of limited cloud brightening are likely to be minimal, and stresses that any effects would trail off within weeks of shutting it down. But he too believes it might be premature for real-world tests. Acting too precipitously could sow further skepticism, limiting long-term options, Caldeira said.

"To me it seems prudent to hold back on doing field experiments, mostly because I'm afraid of backlashes," he said.

At a minimum, any limited field tests should be conducted by entities like the National Science Foundation, and include rigorous review processes and government participation, Long and other scientists stress.

Thinking long-term

Caldeira suggests that the world might have to literally feel the heat - perhaps witnessing mass starvation or the migration of millions of climate refugees - before geoengineering becomes politically palatable.

By then, though, it could be harder to conduct research in a deliberative, dispassionate manner. That's why some want to move ahead sooner rather than later.

"We'd just like to examine the ideas we're involved with," Latham said. "And ideally, if they work, just pop them on the shelf."

Despite some reports to the contrary, Neukermans and his colleagues emphatically deny that they intend to test the technology on actual clouds. If they manage to build working prototypes, they plan to turn them over to academic or government researchers. They're content to leave the deployment as well as the debate to others, and just do what engineers do: solve the tricky technical puzzle before them.

But there is another force driving Neukermans, a father of four and grandfather of eight. In his eighth decade, after a lifetime of inventions, he would like to use his talents to devise one more - one that would really count.

"The next generation is a consideration for all of us," he said. "I hope we never have to use this, but if we do, we'd make a contribution on a scale you could never envision."

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Pier 70 project set for presentation

John Wildermuth
Updated 6:55 pm, Wednesday, January 16, 2013

A $242 million plan for a new, mixed-use development at historic Pier 70 will be presented to the Port Commission next week, part of the city's high-priority effort to revitalize underused sections of San Francisco's aging waterfront.

The project, which is in its early stages, calls for putting shops, restaurants, small manufacturers and a bayfront park on a 28-acre site that is expected to include about 1,000 apartments and 2.2 million square feet of office space over 15 to 20 years of construction.

Forest City Development, which has exclusive rights to that section of the sprawling pier, has been working for months surveying the site to better understand the physical requirements for construction and how to integrate any construction into the feel and fabric of the surrounding Dogpatch neighborhood.

"We went out and spent six months working to capture the character of the neighborhood," said Jack Sylvan, a Forest City executive. "We want to understand what makes that part of the city tick."

The effort included having Wendy Macnaughton, a local artist and illustrator, walk around the Dogpatch neighborhood to put together a graphic look at the area and its people.

Shipbuilding center

For nearly a century, Pier 70 was a shipbuilding center, turning out everything from ocean schooners and ferryboats to warships that fought from the Spanish-American War through Vietnam.

The BAE Systems ship repair yard there remains an important part of the city's maritime industry.

The 65-acre pier, which extends along Illinois Street from Mariposa Street to 22nd Street, had more than 18,000 workers on the site when World War II ended in 1945.

But age and decay, combined with the changing face of San Francisco's waterfront, has forced the cash-strapped port to look for other uses.

The city already has approved a $100 million project by Orton Development to rehabilitate and reuse a half-dozen historic brick buildings in the pier's historic core along 20th Street. BAE Systems will stay, and the port and the city plan to develop bayfront Crane Cove Park along the northern edge of the site.

That leaves Forest City with the rest of the pier, an area that includes some historic buildings but also land now being used for scrap metal salvage, vehicle storage and the city's tow and impound lot.

Extend Dogpatch area

The key is to "extend the Dogpatch neighborhood into the development," said Alexa Arena, a senior vice president for the developer. "We want to provide interior streets and alleys to create a neighborhood center."

Plans now call for rehabilitating the 118,000-square-foot, 1941 Plate Shop, where the metal for the hulls of the warships was fabricated, and creating a large space for shops, light manufacturing and creative uses.

A finger of open space would extend from the building to the bay, where an 8-acre shoreline park would continue along a promenade past the old concrete slips where the newly completed ships once were launched.

The rest of the site would include offices earmarked for tech companies, along with apartment buildings and room for a variety of small businesses in a low-rise central section.

Mix of buildings

But the plans also include trade-offs and compromises guaranteed to raise concerns among neighbors and waterfront preservationists.

Early drawings include a pair of 17-story, 230-foot-tall office buildings, one of them on the bayfront. There's also a similar-size residential building on Illinois Street that would include about 200 apartments.

The high-density development is needed to allow the smaller, more pedestrian-friendly buildings in the central section of the pier, Sylvan said, making the project both financially viable and friendly to residents, workers and visitors.

"What you get from having height on the edges is human-scaled development in the center," he said. "They need each other. The lower-scale core relies on heavy density elsewhere on the site."

Several years away

There will be plenty of time to wrangle over the details of the project, which is still more a concept than a finished design.

While the developers hope to have both the Port Commission and the Board of Supervisors sign off on the term sheet for the project by spring, the environmental impact report, which will take a detailed look at the effects the project will have on the surrounding area, is expected to take at least two years to complete.

"If we run fast, we could have the project approved by the end of 2015 and begin construction by 2016," Sylvan said.

Dogpatch art

Artist-illustrator Wendy Macnaughton was hired by Forest City Development to put together an artist's view of the Dogpatch neighborhood. Her work can be seen on the Pier 70 project website at www.pier70sf.com

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Scientist sees the light on solar energy

James Temple
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One day in the summer of 1980, Heinz Frei was working on his postdoctoral project at UC Berkeley, when his mentor walked up to his desk in Hildebrand Hall.

George Pimentel, the late scientist whose name now adorns the chemistry lab, had just returned from a Department of Energy solar research conference. He said he was surprised that one presentation after another had focused on ultraviolet light, which represents just a tiny fraction of the energy in sunlight.

Infrared, which makes up far more of the energy reaching the Earth, had hardly earned a mention. The real potential to exploit sunlight lay in this "long" end of the light wavelength spectrum, Pimentel told Frei, yet no one seemed to be exploring the possibility.

Would he like to set up a research group at Lawrence Berkeley National Laboratory to try?

Frei had been considering moving back to his native Switzerland. Instead, he said yes on the spot.

Without knowing it at the time, the decision would represent his first step on a long path to the development of artificial leaves, a potentially game-changing technology that can wring liquid fuels from sunlight, water and carbon dioxide.

For most of his childhood, Frei had expected to take over his parent's office supply business. But during a high school science class in his hometown of Lucerne, near Zurich, he found himself captivated by molecules.

"The fun of gaining knowledge and understanding phenomena around us, that really fired me up," he said.

Frei decided to go into chemistry rather than retail, eventually earning a doctorate at the Swiss Federal Institute of Technology. He went on to win a fellowship that allowed him to pursue the postdoc work at Berkeley.

He was specifically drawn by the chemistry department's sophisticated lasers and spectrometers, which allowed him to conduct highly controlled experiments using infrared light to induce chemical reactions.

Following his conversation with Pimentel, he began research at the Calvin Lab at Lawrence Berkeley that would help lay critical foundations for artificial photosynthesis. Notably, it allowed scientists to take advantage of a wider slice of the light spectrum to trigger chemical reactions.

The words "global warming" were rarely uttered in the early 1980s. But even then, Frei suspected that filling the atmosphere with carbon dioxide was creating a growing problem for society that his research could help to address.

"I felt that we needed to ultimately make everyday chemicals and fuels from sunlight," he said. "I believed that in the long run, at some point, renewable energy would become a real issue. It took a while."

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Is rebuilding in hurricane zones wise?

Carolyn Lochhead
Updated 11:29 pm, Friday, January 18, 2013

Washington -- Denise Tortorello, a real estate agent at Riviera Realty in Point Pleasant, N.J., said she can't tell yet where property values are headed since Hurricane Sandy demolished a string of beach towns built on a slender strip of barrier islands in the Atlantic.

"I'm sitting in my office, and I'm looking at the National Guard right outside out my window," she said. On a December day, the temperature outside was 65 degrees.

Just south in Mantoloking, second homes sell for up to $10 million. Many were destroyed, along with roads, sewer lines, gas lines, power lines. "They're replacing everything," Tortorello said. "The general consensus is, 'It's not going to happen again. It was the 100-year flood.' "

But Sandy is the future, climate scientists said. As carbon dioxide emissions blast past worst-case scenarios, rising sea levels and storm surges will reshape every U.S. coastline, from San Francisco to Houston to New York. It is only beginning to dawn on Americans, half of whom live on the coasts, that their future is a battle against the sea.

In the impulse to rebuild from Sandy, much of it financed by the federal government, big questions need to be answered. What to protect, and how? Where to retreat? Where to stand fast?

San Francisco International Airport is in danger of inundation, as are the airports of Oakland, Boston, New York, Washington, D.C., and elsewhere. Houston sits atop a flood plain, along with much of the nation's petrochemical industry and a quarter of its gasoline supply.

Connecticut has more than 100 sewage treatment plants on its battered shoreline. Manhattan might be saved, but Breezy Point? Will American cities build giant sea barriers, like Rotterdam, Netherlands, and London? Or vast underground water-holding chambers like Tokyo? At what cost?

Billions for sea walls

The prospects are staggering. Naval bases, power plants, ports, highways - trillions of dollars of investment - sit on U.S. coasts because it once made sense to put them there. As people flocked to the shores, tiny beach towns became cities. Congress is hardly maintaining roads and bridges; its appetite for giant new sea walls around New York Harbor has yet to be tested.

"You may be able to have the government rebuild New Orleans, and maybe you could have the government rebuild from Sandy," said John Englander, author of "High Tide on Main Street," a book on how rising seas will affect the coasts.

"But as sea level rises and reclaims shoreline all around the United States and all over the world, governments can't afford to reimburse that. It's not just Miami, it's Charleston, it's downtown Seattle, it's Sacramento, it's every coastal city and city on rivers."

A $14.5 billion system of barriers now protects New Orleans. But barriers won't work for Miami, sprawling just 6 feet above sea level on porous limestone.

San Francisco planners dismissed large barriers at the Golden Gate early on. Shielding the bay would require the equivalent of two dams to allow water to flow in and out, fitted with locks for ship traffic, said Will Travis, senior adviser to the Bay Area Joint Policy Committee, which coordinates planning by four regional agencies.

"If you just put a dam across the Golden Gate, well, that would be fine," he said, "but then you would kiss the bay goodbye and the whole ecosystem."

Since Hurricane Ike devastated Galveston, Texas, in 2008, narrowly missing the Houston Ship Channel and its petrochemical complex, Houston has been debating the "Ike Dike," a 62-mile, 17-foot wall along Galveston Island and Bolivar Peninsula, with giant sea gates into Galveston Bay.

The Ike Dike remains "an advanced concept" according to its creator, William Merrell, chair of marine sciences at Texas A&M University, but has not proceeded for lack of money and worries about the wisdom of such an undertaking. Cost estimates range from $6 billion to triple that.

Coasts going under

The rate of sea-level rise has doubled since 1990; it is expected to accelerate with the rapid melting of the Greenland and West Antarctic Ice sheets. Greenland set a record for melting in July. Arctic sea ice reached a record low in September.

Carbon dioxide concentrations are the highest they've been in 15 million years, according to a World Bank report, "Turn Down the Heat," that last month summarized research. At today's emissions rate, the planet could warm by 4 degrees centigrade by the end of the century, an event "unknown in human experience," the report said. The coolest months of the year will be "much warmer" than the warmest months now.

Last year broke U.S. records with 10 severe weather events that cost more than $1 billion each. As the oceans warm, storms become more intense. The report warned of increasing heat waves, droughts, floods, species extinctions and sea-level rise, citing heat waves in Russia and Europe and floods in Pakistan in 2010, the Plains heat wave last year, and the U.S. drought this year.

Greenhouse gas emissions already are "above the absolute highest scenario" that was projected by the Intergovernmental Affairs Panel on Climate Change in its latest report, in 2007, said S. Jeffress Williams, a scientist emeritus at the U.S. Geological Survey at the Woods Hole Science Center in Massachusetts. Most coastal cities are "built within a couple of meters of sea level, and they're all extremely vulnerable."

Under high-emissions scenarios, seas are expected to rise from 3 to 4 feet this century. Gradual coastal inundation is feared less than destructive storm surges, such as Sandy's, which launch from a higher sea platform in storms made more intense by the warming ocean.

Developers of Treasure Island in San Francisco Bay, constructed of landfill at sea level, have a plan considered by some a national model. They have set aside the perimeter for a levee that will rise with the seas.

"The consensus was the best approach for sea-level rise is adaptive management," said Stephen Proud, project manager for Lennar Urban, one of the developers.

Coastal development encouraged

Coastlines are ecologically rich areas, pressed by development on one side, and rising seas on the other. In their natural state of dunes, marshes, bayous, estuaries, barrier islands and other shifting features, they are designed by nature to absorb storms. Much of the recent storm damage has been concentrated on barrier islands - the Rockaways in New York, New Jersey's Barnegat Peninsula and Galveston Island and Bolivar Peninsula in Texas.

"People built palatial houses, and we are now trying to protect the houses by making the sandbar stay in one place," said Nicole Heller, an ecologist at Duke University. "That's not what a sandbar does."

Far from discouraging building on the coast, Congress encourages it by subsidized flood insurance, disaster aid and flood-control projects such as levees. California has more levees than any state, and they so encourage unwise development behind them that economists have dubbed it the "levee effect." The Sacramento-San Joaquin River Delta "is almost entirely below sea level," according to the Environmental Protection Agency.

State and local governments further encourage building in vulnerable areas through zoning, building codes and provision of roads, sewers and other infrastructure. New Jersey is rebuilding Highway 35, sitting on a barrier island and washed away by Sandy, just as North Carolina repeatedly reconstructs Highway 12 on its Outer Banks.

"This is why so many people buy ocean-front homes," said Rob Young, director of the Program for the Study of Developed Shorelines at Western Carolina University.

"Take a place like Dauphin Island, Ala., that's been whacked by tropical storms 10 times in 30 years, and you say, 'Gosh those people must be crazy to rebuild.' Well, they're not crazy. They're making a perfectly reasonable economic decision. It's the rest of us that are crazy."

Michael Tetreau, first selectman of Fairfield, Conn., heavily damaged by Sandy, said, "We have to work within zoning laws. We can't unilaterally take someone's property away. The ocean might do it, but we can't do it."

Who says 'don't build'?

Tetreau said cities have an obligation to their citizens to rebuild infrastructure and that the question is better posed to the federal government, which must decide whether to insure homes in dangerous areas. "Somebody pointed out that things like Interstate 95 and the railroad tracks are not that high above sea level right now," Tetreau said.

He said he was asked a year ago why the town's sewage-treatment plant was built so close to the sea. "It's like, because things flow

downhill," he said. "That's the lowest point. You've got to put it there. At some point, if the lowest point is underwater, you have to back it up."

Only 100 or so buildings out of 5,900 on the Texas coast's Bolivar Peninsula survived Ike. Property values dropped 30 percent right after the storm, said Anne Willis, a Realtor with Swede's Real Estate in Crystal Beach, Texas.

Soon though, "Lots started selling like crazy, because people felt they could get a bargain," she said. The price decline "only lasted about a year, and then they've gone up now back to where they were before Ike. Rebuilding has been crazy around here."

The government offered buyouts, she said, "but a lot of the people that took them, they bought somewhere else and built with the money. ... Actually they're building bigger. If they had 1,000 square feet, they just build 2,000 square feet. I mean, everybody's building bigger."

Federally subsidized flood insurance is available to Bolivar homeowners, and with help from the Federal Emergency Management Agency, "they rebuilt the roads, they rebuilt the great big joint fire station, all the infrastructure's back," Willis said. "Back better than ever."

Joe Piscitelli, a Milford, Conn., Realtor who covers 60 miles of shoreline on the Long Island Sound, said in some low-lying towns such as East Haven, "We've seen a drop in prices and a big fear, actually, of the water." Properties there have been sitting unsold since Hurricane Irene struck in 2011.

"You couldn't give away a piece of property right now," he said. "But the way we are as Americans, by next spring when the sun is out and it's 80 degrees and the seals are out there swimming and people are out in their sailboats, (we will) forget about it. People won't even remember the storm. They'll just be thinking of the magic of the water."

Flood insurance reformed

Last summer, Congress made several reforms to the flood insurance program that will raise premiums, update flood maps and consider climate change for the first time. As many as 40 percent of homes that have collected multiple payouts for flood losses are not even mapped as high-risk areas by FEMA, which would push up premiums, said Eli Lehrer, president of R Street, a conservative think tank that worked with environmental groups to get reforms.

President Obama and Vice President Joe Biden made promises to rebuild areas that Sandy destroyed. Representatives of the nine states that were declared disaster areas after Sandy are clamoring for federal aid to rebuild while promising to do so intelligently.

"A nation that put a man on the moon can figure out how to rebuild and recover but also do it smarter and more cost-effectively than we've done in the past," said Sen. Richard Blumenthal, D-Conn. "Doing the same thing again and again is not going to work."

Members of Congress from New Jersey and Maryland want the Army Corps of Engineers to rebuild beaches and dunes that had already been rebuilt at a cost of hundreds of millions of dollars but were swept away by Sandy. Maryland representatives argued that beach replenishment saved Ocean City.

Coastal scientists said there may not be enough sand on the Continental Shelf to continue rebuilding beaches.

"We clearly need to have a discussion as to whether or not federal taxpayers should spend $1 billion to re-engineer all of the beaches of New Jersey to provide some supposed protection for private property along the shorelines," said Young, of Western Carolina University.

"Sooner or later we will retreat, and the question is how you do it," he said. "The way we could begin having some of these coastal communities take a step back from the hazard would be if we cut off subsidies, and they had to finance the risk themselves."

Stanford University political scientist Neil Malhotra published a paper after Hurricane Katrina that found voters punish politicians who prepare for disasters and reward those who respond to them.

If a town imposes costly building codes and restrictive zoning and survives a hurricane, "No one appreciates work that was done because they've already voted that guy out," said Ben Strauss, director of the program on sea-level rise at Climate Central, a nonprofit educational and research group.

"The neighboring town may be flattened, but their leader goes to Washington and collects aid to build back. That leader, who made no plans in advance, is a hero."

Costly coastal armor

A debate rages among architects and coastal scientists about whether to "armor the coast" with hard structures or to rebuild or create

barrier islands, reefs, estuaries and other "green infrastructure."

Catherine Seavitt Nordenson, an associate professor of landscape architecture at City College of New York, said the giant barriers envisioned for New York Harbor would damage surrounding areas and are prone to catastrophic failure if oceans overtop them. She called for redundant, permeable structures incorporating gradient edges that absorb wave energy, such as artificial barrier islands.

"No storm surge barrier is going to reduce the volume of water that's coming in a surge," she said. "It's deflecting against that barrier and bouncing elsewhere."

That means anyone who is not behind a barrier sees bigger storm surges.

A huge experiment with green infrastructure is under way on the Louisiana coast.

John Kostyack, vice president of wildlife conservation for the National Wildlife Federation, an environmental group, hopes that BP's multibillion-dollar oil spill settlement will help pay for a state plan that calls for reconstructing parts of Louisiana's coastal wetlands.

These have been severely damaged, in part by the extensive levee system built in the last century to prevent the Mississippi River from flooding. Flooding allowed the river to dump sediment along the coast, replenishing wetlands.

The new plan includes physically piping dredged sediment to re-create wetlands as the river once did on its own.

Big cities face bigger, costlier and more perplexing issues.

Large parts of Silicon Valley and downtown San Francisco face inundation. Much of the land ringing the San Francisco Bay is landfill built only to current sea level. The South Bay rests on former orchards that were irrigated with groundwater, causing the land to sink below sea level. The bay is ringed by major highways.

"Using rough figures, by midcentury we could have somewhere on order of 280 square miles under water," said Travis of the Bay Area Joint Policy Committee. "That's $60 billion worth of transportation infrastructure, schools, houses, a quarter-million people."

Who goes under?

Choices will be excruciating.

"I think it goes without question that we will want to protect downtown San Francisco as long as we can, and the airports and Silicon Valley," Travis said. "But what happens when you get to communities like East Palo Alto and West Oakland and Richmond, where if you do a cost-benefit analysis, you say, these homes aren't worth all that much, and it might not be worthwhile to protect them? But what if you live there? What if it's your home, and that's where your parents grew up, your grandparents, and your church is there and your schools, and your whole social structure and everybody you know? It's like the lower Ninth Ward in New Orleans."

He said people often find their house on maps that show areas of projected flooding and think they are safe if they're on a hill.

"It won't do you any good if you live on a hill if you can't get down onto the freeway to get to work, and your sewage treatment plant goes under water and you can't flush the toilet, and the power plants go out," Travis said.

Lindy Lowe, who heads the Adapting to Rising Tides project for the Bay Conservation and Development Commission, a state agency that works on the bay, said her group is trying to determine precisely what parts of Alameda County are vulnerable.

When the group began looking at Oakland International Airport, they realized that not only the airport but the roads leading to it would be flooded.

"That was something we hadn't realized," she said. "Protecting the runway wouldn't protect the function of the airport, because you wouldn't be able to get to it."

Phil Bedient, a professor of environmental engineering at Rice University who directs the Severe Storm Prediction, Education, Evacuation from Disaster (SSPEED) Center, said, "You need to protect the Houston ship channel and the ship channel industries, because it would be a major hit on the U.S. economy, if that took a direct hurricane hit. "

But to try to protect the entire shoreline would cost tens of billions of dollars, he said.

He doesn't think giant sea barriers will fix the problem. "These storms are big, they're complex, and you simply cannot treat this like we are going to produce a single flood-control solution here that will work forever and ever," Bedient said. The cost of doing that would be astronomical." Asked to define astronomical, he said, "Hundreds of billions."

Dutch consultants have become the rage among coastal planners, including those in San Francisco, New York and Houston.

"But getting to the next step of actually figuring out what the options are, which one to choose, how to pay for it, and then going ahead and doing it, is some years down the road," Travis said. "It could very well be too late."

House approves Sandy aid

The political tempest stirred up by Superstorm Sandy appears to have moved on after wreaking havoc among congressional Republicans divided over how much aid to allocate to the victims.

In a 241-180 vote Tuesday, the House approved $50.5 billion in disaster relief for Sandy victims. The Senate is expected to accept the measure this week and send it to President Obama despite some Democratic concerns that it doesn't do enough.

House Democrats supported the aid package in large numbers Tuesday but substantial Republican backing was needed for its passage in the GOP-controlled House. There were 192 Democrats and 49 Republicans voting to pass the measure.

The Senate approved a $60.4 billion measure in the final days of the Congress that expired Jan. 3, but House Speaker John Boehner unexpectedly postponed the vote as he struggled to calm conservatives unhappy that the House had approved a separate measure raising tax rates on the wealthy.

Associated Press

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Architects apply high design to high tides

James Temple
Updated 4:12 pm, Saturday, January 19, 2013

One day in the early 1980s, Byron Kuth walked into a studio at the Rhode Island School of Design and spotted renderings that stopped him in his tracks.

He asked around about the artist and soon tracked down a brunette with fine features named Elizabeth Ranieri, an encounter that would mark the beginning of a long personal and professional partnership.

At the time, the school was drifting away from postmodernism and settling around "unprecedented realism," as professors like Rodolfo Machado asserted that all public structures were fair game for forward-thinking design, even highway clover leafs, retaining walls and, perhaps, levees.

That philosophy is evident in Folding Water, the now husband-and-wife architecture team's designs for a new kind of shoreline protection, which could combat sea level rise on the San Francisco Bay.

"We wanted to place a new mark into the bay, with minimal impact, but a very graceful and elegant presence," Ranieri said.

Molded by music

Kuth grew up in the Rubber Belt of Cleveland. But his love of music and design led him to the California Institute of the Arts in Valencia (Los Angeles County), the incubator for world-class illustrators and performers founded by Walt Disney.

In between design classes, Kuth learned to play a variety of little known and hard to pronounce percussion instruments (give "mridangam" a whirl). He eventually landed in India to study Carnatic music.

In the late 1970s, he split his time between a world music ensemble in New England and the Connecticut office of Charles Moore, the architect best known locally for designing the Sea Ranch community. In 1983, Kuth committed to the latter craft and enrolled at the Rhode Island School of Design.

Building as art

Ranieri grew up in Franklin, Mass., the last stop on a commuter rail line out of Boston's South Station.

Her father was a plumber-turned-contractor-turned-developer. She remembers the family home being cluttered with architectural renderings. On weekends, Ranieri would sometimes accompany her dad as his crew razed sites and relocated homes.

Those peeks into the subterranean world of pipes and foundations sparked an interest in infrastructure and public space that eventually led her to the Rhode Island school as well.

In the late 1980s, the couple set up Kuth/Ranieri Architects in San Francisco, where they quickly built a reputation for designing small but highly refined buildings. Over the years, they've also worked on a number of theoretical public works projects, increasingly with an environmental focus.

Which category Folding Water ultimately falls into - real or research- remains to be seen. But the couple are certainly pursuing it as the former.

They've assembled an advisory board of experts in hydrology, engineering and energy. They're also working with students and professors at the UC Berkeley College of Engineering to evaluate and model certain technical components.

The group is looking at Richardson Bay, along the southern edge of Marin County, as a possible pilot site for the levee. It's relatively shallow, narrow and isolated, critical factors for reducing costs and environmental impacts. It might be also a promising location for a proof of concept because Marin residents already regularly grapple with high sea levels, as was evident during the king tides of mid-December, when parts of Shoreline Highway and other areas flooded.

"There's an abstraction to this crisis," Ranieri said. "But here you have a problem in real time that people are upset about."

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California falling short on rising seas

James Temple
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On the night of Jan. 31, 1953, a hurricane descended on the northeast coast of the Netherlands, whipping up high spring tides into 18-foot surges.

As dike after dike failed, floods washed over at least 600 square miles, leaving hundreds of thousands homeless and killing more than 1,800.

The tragedy set off a decades-long campaign to ensure that it never happened again, as the nation adopted an essentially zero-tolerance policy for mass flooding. They erected a closed system of levees built to withstand all but a 1 in 1,000 years flood, sometimes forsaking ecosystems in the name of safety.

As the Bay Area begins planning for rising sea levels that could expose hundreds of square miles to flooding by 2050, the question becomes: What level of risk tolerance are we comfortable with?

California has done more than most states to prepare for the challenges of climate change, but when it comes to the dangers of sea level rise, experts worry that the state isn't doing nearly enough.

'A lot of risk'

In late 2008, Gov. Arnold Schwarzenegger signed an executive order directing the California Resources Agency and other groups to study the risk of sea level rise, while requiring state agencies to consider those projections in future project planning.

But accounting for sea level rise in new developments does nothing to address the vastly larger problem of vulnerable shorelines and communities that already exist. And at this point, no state department has clear authority to oversee such efforts, much less a budget.

"There's a lot of risk among existing infrastructure and communities and there is no single agency responsible for that," said Heather Cooley, co-director of the water program at the Pacific Institute.

Absent a state department or law, it will be difficult to impossible to get the dozens of local governments that touch San Francisco Bay to act in any kind of logical lockstep on what will be a huge problem, several observers said.

So far, the agency spearheading most of early regional research into sea level rise is the San Francisco Bay Conservation and Development Commission.

Among other efforts, the commission is working with several dozen local, state and federal organizations to carefully evaluate the vulnerability of the Alameda County shoreline from Emeryville to Union City. They hope to establish a process that other areas around the bay can follow.

To date, the working group has created detailed maps that highlight areas exposed to high tides and 100-year floods, under 16-inch and 55-inch sea rise scenarios. Even the low-end estimates show water inundating considerable portions of Oakland International Airport, Hayward and Union City.

The wide-open question is what to do about it.

Lindy Lowe, BCDC's project lead on the Adapting to Rising Tides effort, stressed that they're just beginning the process of identifying potential strategies.

But rather than one dramatic fix, she said, it will probably come down to a combination of hard and soft approaches that can be used at specific sites as rising tides require: new levees, raised seawalls, expanded wetlands and improved drainage.

At the same time, Lowe said, part of adapting to the region's new reality may simply mean better preparing communities and emergency responders for occasional flooding. Some cities will simply balk at the high price of rigorous protection.

"We as a society thus far have taken the 'Well, it will happen every so often and we'll try to make the best of it' approach," she said. "So people get wet, get injured or die. That attitude may change as this affects us more often."

Attitudes certainly shifted after the North Sea flood of 1953, as well as the more recent examples of Hurricane Katrina and Superstorm Sandy. But the Bay Area has the option of learning from those earlier tragedies, instead of waiting around for its own.

Adequate standard?

One critical assumption those events call into question is the 100-year flood standard.

The long tradition in the United States is building shoreline protections to hold back flood levels that have a 1 percent chance of occurring in any given year. It's also the worst-case scenario explored in BCDC's shoreline analysis.

But a growing number of experts say it's already an inappropriate standard for urban centers - and one that could drastically understate the risk in the near future. The Netherlands, where about a quarter of the country is below sea level, has been shifting to a 10,000-year standard.

"The 100-year standard has driven levels of protection below economically optimal levels, has encouraged settlement in areas behind levees, and resulted in losses of life and vast federal expenditures following major flood and hurricane disasters," concluded a committee organized by the National Research Council to draw lessons from Hurricane Katrina.

Scrambled picture

The bigger problem is that no one can say what a 100-year flood looks like anymore. Scientists say that global warming is increasing the frequency and intensity of extreme weather events, scrambling the math of risk analysis based on historic patterns.

In other words, planning assumptions that experts already argue are inadequate for population centers might also be plain wrong. If so, the little planning work under way for San Francisco Bay could understate the risks to residents and property in the decades ahead.

"For a place like San Francisco, or the low-lying parts of the Bay Area, the annual probability of major flooding ought to be pretty low because you have a lot of people there," said John Christian, a member of the National Academy of Engineering who worked on the Katrina report. "We're dealing with a very rapidly changing environment that has made prediction difficult."

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Preparing the bay for rising sea levels

James Temple
Updated 4:11 pm, Saturday, January 19, 2013

On a sunny Friday afternoon last fall, a Grand Banks trawler idled at the mouth of Richardson Bay, giving those aboard a close look at a battleground in the fight against climate change.

The lobster claw-shaped estuary defines and occasionally redefines the southeastern edge of Marin County, a shoreline area dotted with expensive homes, shops and restaurants. During the king tides near the turn of the year, when sea levels reach their zenith, water overwhelms the banks and marshes, flooding parts of Shoreline Highway and other roads.

That susceptibility makes Richardson Bay a canary in the coal mine of Bay Area sea level rise. As global warming threatens to transform today's high tides into tomorrow's low ebb, those inconvenient floods could turn into tragedies.

But the estuary's vulnerability also makes it an ideal site to try bold approaches to shoreline protection.

Which is why architects Elizabeth Ranieri and Byron Kuth chartered the trawler that October afternoon. Peering out from beneath sunglasses and baseball caps, they surveyed the stretch from Sausalito to Belvedere and imagined their designs for an entirely new kind of levee, a barrier with porous walls that could protect the shore as well as the ecology of the bay. "Sea level rise is essentially right around the corner," said Kuth, a husky man with a reddish goatee. "We have to begin to think now about how we introduce innovative ideas."

Fight or flight

The oldest continually operating tidal gauge in the Americas descends into the shores along Crissy Field in San Francisco, tethered beneath a breakwater that doubles as a nest for Elegant Terns. The original instrument and its descendants have recorded the ebb and flow of coastal sea levels since 1854, when the United States Coast Survey installed it to help ships navigate the treacherous Golden Gate.

Over the last century, the gauge has tracked a gradual 8-inch rise in coastal waters. But by 2050, as global warming melts ice caps and swells the seas, the gauge's readings could leap almost 1 1/2 feet, scientists say.

For Bay Area residents, it will be one of the most obvious effects of a changing climate. Not just Richardson Bay, but land equivalent in area to six San Franciscos could regularly flood, inundating vast swaths of the region's airports, high-tech campuses and the homes of more than 100,000 residents, according to the San Francisco Bay Conservation and Development Commission.

And the toll will only climb from there, with sea levels expected to surge as much as 6 feet by 2100.

Ultimately, there are few good options for confronting this challenge.

"There are two reactions to dealing with sea level rise; there is fight and there is flight," said Will Travis, senior adviser to the Bay Area Joint Policy Committee, which coordinates planning efforts among regional agencies.

That means either abandoning low-lying areas or erecting shoreline protection, be it traditional structures like dams or new concepts like the one Kuth and Ranieri have in mind.

Or both. In the end, planners studying this issue believe that the realities of time, finances, politics and lethargy may force the region to make hard choices about what to protect, what to abandon and what level of risk the region is willing to live with.

Folding Water

What might seem the obvious solution to Bay Area sea level rise is to erect a giant dam across the Golden Gate, cutting off the rising tides at the bay's bottleneck. But besides marring a signature landmark and running up a huge bill, such a barrier would halt the critical underwater circulatory system that exchanges sediment, salinity and sea life between the bay and open ocean.

These are the typical problems with "hard" shoreline protection: high economic, environmental and aesthetic tolls.

In late 2008, BCDC sponsored the "International Rising Tides" competition, calling on architects and designers to propose more creative approaches.

Kuth and Ranieri, the husband-and-wife founders of a namesake architecture firm in San Francisco's North Beach, submitted a proposal that was equal parts high-tech and high-design. They envisioned a "ventilated levee" that minimized impacts on the

environment and bay views. BCDC's judges selected the project, dubbed Folding Water, as one of six winners of the competition.

Picture it as a narrow capital 'V' that sits mostly beneath the surface of the water, but stretches across the mouths of bay inlets. The top of the stem closest to the shore could double as a dock, and the edges might include locks for small craft. The oceanside stem would be capped with a mechanical wall that tilts higher as sea levels rise, creating a waterfall that drops into the space between.

Anyone standing on the shore would see a nearly natural maritime scene: a dock, the bay and a small waterfall when the levee is at work.

A system of "pump ventilators" would be built into the walls, returning excess water to the sea while mimicking the effects of tidal exchange. Natural pressure would force ocean waters and small sea life into the estuary through one side of these tubes, while the mixed water would be pumped back out the other side.

Protecting all the low-lying areas at risk along San Francisco Bay would require 10 to 15 levees, each of which could be calibrated to maintain the natural ecology of a specific cove.

"We thought of it like a pacemaker," Ranieri said, "a unique piece of infrastructure to help regulate that body of water on its own terms."

Folding Water would operate autonomously, using a system of sensors, smart software and clean energy from tidal turbines and geothermal wells. Working out the technical details will be a challenge, but outside observers say the basic concept is sound.

"Whatever we can do to create a more natural system to protect ourselves is a good thing," said Peter Wijsman, a program manager at Arcadis, a Netherlands firm that designs and builds dams and levees. "If it's something that can adapt itself as sea levels are rising, then that is definitely a favored approach."

Of course, even the prettiest levee in the world with the lightest ecological impact is sure to spark an outcry from environmentalists and residents in the Bay Area and beyond.

Then there's the question of costs - and who would pay them. No one really knows the price for one Folding Water, let alone 15.

It would surely be substantial, however. A 2009 report by the Pacific Institute in Oakland estimated that it would cost $14 billion (in year 2000 dollars) plus $1.4 billion in annual maintenance to armor the California coast line for sea level rise, with the majority of the spending in the Bay Area.

BCDC, however, estimates that the projected sea level rise by 2100 puts $62 billion in shoreline development at risk.

"It's not a matter of how much it's going to cost, but what's the cost of not doing it?" Kuth said.

'We have time'

Brad McCrae, regulatory program director at BCDC, organized the Rising Tides competition to solicit bold ideas to combat sea level rise. But he stresses that we're not at the point where we know enough about the specific vulnerabilities around the bay, or the range of options, to seriously consider major shoreline protection projects like Folding Water.

"We don't have to figure it out entirely right now," he said. "We have time, and that's a good thing."

Still, as the fossil fuel emissions blamed for climate change blow past the predictions of just a few years ago, the problem could creep up faster and higher than current models suggest.

And major infrastructure projects don't go up overnight: it took more than 13 years just to begin construction of the new east span of the Bay Bridge, and that was after the Loma Prieta earthquake tragically underscored the bridge's vulnerability to natural disaster.

Meanwhile, areas along San Francisco's Embarcadero, Peninsula beaches and, of course, Richardson Bay are already flooding with growing frequency. This won't be a problem that starts in 2050; it's here, and will get worse over time.

Whether Folding Water is the answer or not, it's sparking conversations about what's possible and necessary, at a point when few are seriously pondering how to deal with a grave threat.

"I don't know if the ultimate solution will look like Folding Water," Ranieri said. "But we know that the crisis is now."

About this story

This story is part of an occasional series exploring cutting-edge Bay Area research focused on containing climate change.

To read more about architects Elizabeth Ranieri and Byron Kuth, California's efforts to plan for sea level rise and the efforts of other

researchers to combat climate change, and to see videos and graphics on this topic, go to: www.sfgate.com/takingtheheat.

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The Examiner
sfexaminer.com

Repairs to start on Bay Bridge after empty oil tanker hit

By: **Bay City News** | 01/21/13 8:51 PM

Caltrans said it plans to begin making repairs today to the Bay Bridge fenders that were damaged when an empty oil tanker struck the span Jan. 7.

The tanker, the Overseas Reymar, hit the easternmost tower on the bridge's western span around 11:20 a.m. on Jan. 7. There was no oil spill, and no one aboard the 752-foot vessel, which was piloted by bar pilot Guy Kleess, was injured, according to the U.S. Coast Guard.

The fender system worked as it was intended to, and the structure of the bridge was not damaged, according to Caltrans.

AP FILE PHOTO

Caltrans plans to begin repairing the fender that was damaged on the Bay Bridge when an empty oil tanker piloted by bar pilot Guy Kleess hit the section on Jan. 7.

The agency has estimated the damage to the fender system at somewhere between $2 million and $3 million.

A Metropolitan Transportation Commission staff member told the Bay Area Toll Authority Oversight Committee earlier this month that while there is reserve money to pay for the damage, the commission will also try to collect money from the tanker's owner, OSG Ship Management Inc.

Repairs to the fenders, which are made of steel and recycled plastic, are expected to take about four and a half months, Caltrans officials said.

Several investigations into the incident are ongoing.

URL: http://www.sfexaminer.com/local/2013/01/repairs-start-bay-bridge-after-empty-oil-tanker-hit

The New York Times

January 21, 2013

How High Could the Tide Go?

By JUSTIN GILLIS

BREDASDORP, South Africa — A scruffy crew of scientists barreled down a dirt road, their two-car caravan kicking up dust. After searching all day for ancient beaches miles inland from the modern shoreline, they were about to give up.

Suddenly, the lead car screeched to a halt. Paul J. Hearty, a geologist from North Carolina, leapt out and seized a white object on the side of the road: a fossilized seashell. He beamed. In minutes, the team had collected dozens more.

Using satellite gear, they determined they were seven miles inland and 64 feet above South Africa's modern coastline.

For the leader of the team, Maureen E. Raymo of Columbia University, the find was an important clue as she tries to determine just how high the oceans might rise in a warmer world.

The question has taken on new urgency in the aftermath of Hurricane Sandy, which caused coastal flooding that scientists say was almost certainly worsened by the modest rise of sea level over the past century. That kind of storm tide, the experts say, could become routine along American coastlines by late in this century if the ocean rises as fast as they expect.

In previous research, scientists have determined that when the earth warms by only a couple of degrees Fahrenheit, enough polar ice melts, over time, to raise the global sea level by about 25 to 30 feet. But in the coming century, the earth is expected to warm more than that, perhaps four or five degrees, because of human emissions of greenhouse gases.

Experts say the emissions that may make a huge increase of sea level inevitable are expected to occur in just the next few decades. They fear that because the world's coasts are so densely settled, the rising oceans will lead to a humanitarian crisis lasting many hundreds of years.

Scientists say it has been difficult to get people to understand or focus on the importance, for future generations, of today's decisions about greenhouse gases. Their evidence that the gases represent a problem is based not just on computerized forecasts of the future, as is

commonly believed, but on what they describe as a growing body of evidence about what occurred in the past.

To add to that body of knowledge, Dr. Raymo is studying geologic history going back several million years. The earth has warmed up many times, for purely natural reasons, and those episodes often featured huge shifts of climate, partial collapse of the polar ice sheets and substantial increases in sea level.

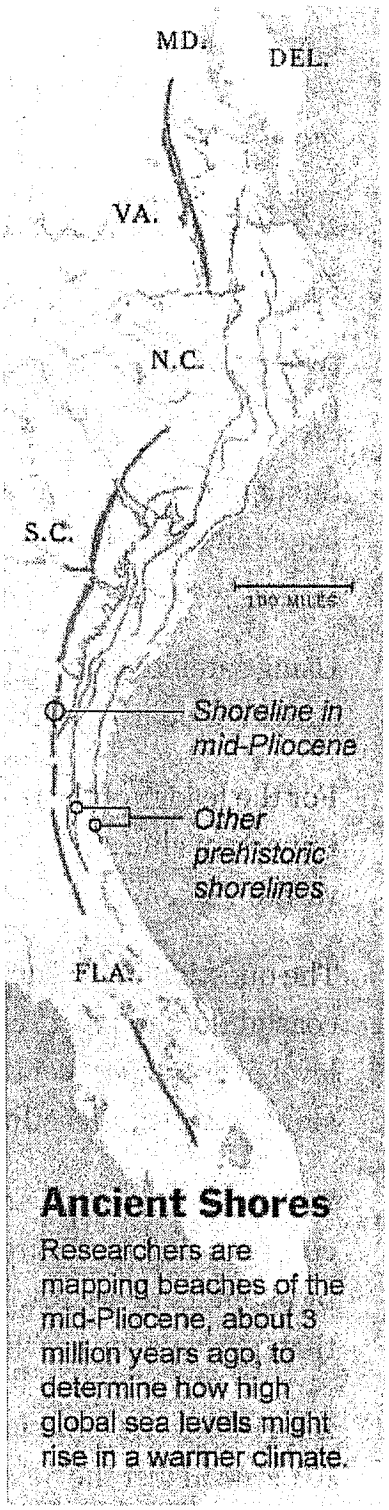
"I wish I could take people that question the significance of sea level rise out in the field with me," Dr. Raymo said. "Because you just walk them up 30 or 40 feet in elevation above today's sea level and show them a fossil beach, with shells the size of a fist eroding out, and they can look at it with their own eyes and say, 'Wow, you didn't just make that up.' "

Skeptics who play down the importance of global warming like to note that these past changes occurred with no human intervention. They argue that the climate is ever-changing, yet humans or their predecessors managed to prosper.

The geologic record does offer startling examples of the instability of the planet. Whale bones can be dug up in the Sahara. The summit of Mount Everest is a chunk of ancient seafloor.

But most climate scientists reject the idea that this history means human-induced climate change will be benign. They add that the fossil record indicates nothing quite like today's rapid release of greenhouse gases and its parallel effect of raising the planet's temperature, changes that are occurring in a geologic instant.

"Absolutely, unequivocally, nature has changed before," said Richard B. Alley, a leading climate scientist at Pennsylvania State University. "But it looks like we're going to do something bigger and faster than nature ever has."



Clues From Fossils

In any given era, the earth's climate responds to whatever factors are pushing it to change.

Scientists who study climate history, known as paleoclimatologists, focus much of their research on episodes when wobbles in the earth's orbit caused it to cool down or warm up, causing sea level to rise or fall by hundreds of feet.

Carbon dioxide, the main greenhouse gas, appears to have played a crucial role. When changes in the orbit caused the earth to cool, scientists say, a large amount of carbon dioxide entered the ocean, reducing the heat-trapping properties of the atmosphere and thus amplifying the cooling. Conversely, when the shifts in sunlight led to initial warming, carbon dioxide emerged from the ocean and helped speed the end of the previous ice age.

Based on this record, scientists like Dr. Alley describe carbon dioxide as the master control knob of the earth's climate. A large body of scientific evidence shows that the current increase in the gas is being caused by human activity, meaning that people are essentially twisting the earth's thermostat hard to the right.

In most of the previous warm periods, some ice remained near the poles, in Greenland and Antarctica. Today, enough water is stored as ice in those regions to raise the level of the ocean roughly 220 feet, should all of it melt.

The fossil record suggests that temperatures slightly warmer than today would not be enough to melt the ice caps entirely. But an increase of even a few degrees Fahrenheit in the average global temperature does appear to cause severe damage. From the last time that happened, about 120,000 years ago, scientists have found more than a thousand elevated fossil beaches around the world.

Many scientists believe that, as a result of human-induced warming, temperatures are already entering the danger zone. They are seeing rapid changes in Greenland and western Antarctica.

"I can merely tell you that every time in recent earth history where we've had these kinds of temperatures for any protracted period of time, two polar ice sheets have catastrophically collapsed," said Jerry X. Mitrovica, an earth physicist at Harvard who collaborates with Dr. Raymo.

Dr. Raymo works at Lamont-Doherty Earth Observatory, a unit of Columbia University just outside New York City. Like many of her colleagues, she is trying to run the movie of the earth's history in reverse, finding an era with temperatures that mirror those expected

before 2100.

She has zeroed in on the Pliocene epoch, roughly three million years ago. The level of carbon dioxide in the air then appears to have been about 400 parts per million — a level that will be reached again within the next few years, after two centuries of fossil fuel burning.

Previous efforts to estimate the maximum rise of the sea in the Pliocene did not take full account of some factors now known to be important.

In Search of Prehistoric Beaches

Two years ago, in hopes of pinning down a better answer, Dr. Raymo pitched an ambitious plan to the National Science Foundation, the federal agency that pays for much of the country's scientific research. She proposed to pull together a worldwide network of expert collaborators: to find, date and measure Pliocene beaches on nearly every continent and then to work with experts in computer modeling to take careful account of all the factors known to alter sea level.

The N.S.F. awarded the group $4.2 million, with one anonymous scientific reviewer declaring that the plan would permit a "far more precise and quantitative prediction of future climate change."

This summer, Dr. Raymo and her team drove hundreds of miles along South Africa's southern and western coasts, scouting for prehistoric beaches.

To collect ancient seashells for laboratory testing, they hiked treacherous paths and descended into old quarries and diamond mines. At one point an Australian researcher, Michael J. O'Leary, and an Italian colleague, Alessio Rovere, climbed a steep cliff face to take measurements, clinging to shrubs as their feet kept slipping.

The team located suspected Pliocene beaches as low as 38 feet and as high as 111 feet above modern sea level. In similar work in Australia and on the East Coast of the United States, the researchers have found Pliocene beaches as low as 33 feet and as high as 295 feet above sea level.

Part of the explanation for such varying elevations, Dr. Raymo said, is that the land itself has almost certainly moved over the last three million years, unevenly — thus raising or lowering beach deposits after they had been laid down.

Scientists have come to realize this can happen anywhere in the world, even far from

geological hot spots, a major factor complicating their interpretation of past sea level. "A lot of the big task we have is teasing apart this dance that the crust of the earth is doing with the level of the sea," Dr. Raymo said.

Over the next few years, her team plans to gather new measurements from most continents, including North America, where the Pliocene ocean encroached as far as 90 miles inland. After several years of work, they hope to arrive at the magic number Dr. Raymo calls Pliomax, or the maximum global sea level rise during the Pliocene.

That figure may help to solve a vexing scientific problem.

A large body of evidence suggests that the ice sheets atop Greenland and the low-lying, western part of Antarctica are vulnerable to global warming. But together, they can supply no more than about 40 feet of sea level rise.

The previous estimates of Pliocene sea level, based on spotty evidence, range from 15 feet to 130 feet above today's ocean, with 80 feet being a commonly cited figure. If Dr. Raymo's work were to confirm such a high estimate, it would suggest that the ice sheet in eastern Antarctica — by far the biggest chunk of ice in the world, containing enough water to raise sea level by 180 feet — is also vulnerable to melting. And if it is, scientists do not fully understand why, because their computer forecasts — acknowledged to be imperfect — suggest most of it should remain stable even in a warmer world.

"Just the mere fact that we know the number will tell us right off the bat, is East Antarctica stable?" Dr. Raymo said. "Or is it a huge risk?"

Thus, if the project is successful, it may put an upper limit on how much the ocean is ultimately capable of rising if temperatures go up as much as expected this century.

But the Pliomax project will not be able to answer what might be an even bigger question: In a worst-case scenario, how fast could the rise happen?

Dr. Raymo and her team share an emerging scientific consensus that the increase in this century will probably be on the order of three feet, perhaps as much as six feet. That would almost certainly require millions of people to evacuate coastal regions.

Calculations by Climate Central, a research group, suggest that once the ocean has risen five feet, storm tides comparable to those of Hurricane Sandy could occur about every 15 years in New York City.

Scientists say that in the 22nd century, the problem would probably become far worse, and the rise would then continue for many centuries, perhaps thousands of years. Recent research suggests the likely rise could be 12 feet by the year 2300, inundating coastal regions around the world.

If the rise is slower than expected, society may have time to adjust, or to develop new technology to solve the problem of greenhouse emissions. But many scientists are plagued by a nagging fear that the opposite will occur — that their calculations will turn out to have been too conservative, and social stability will eventually be threatened by a rapid rise of the sea.

"At every point, as our knowledge increases," Dr. Raymo said, "we've always discovered that the climate system is more sensitive than we thought it could be, not less."

DEPT. OF URBAN PLANNING

ADAPTATION

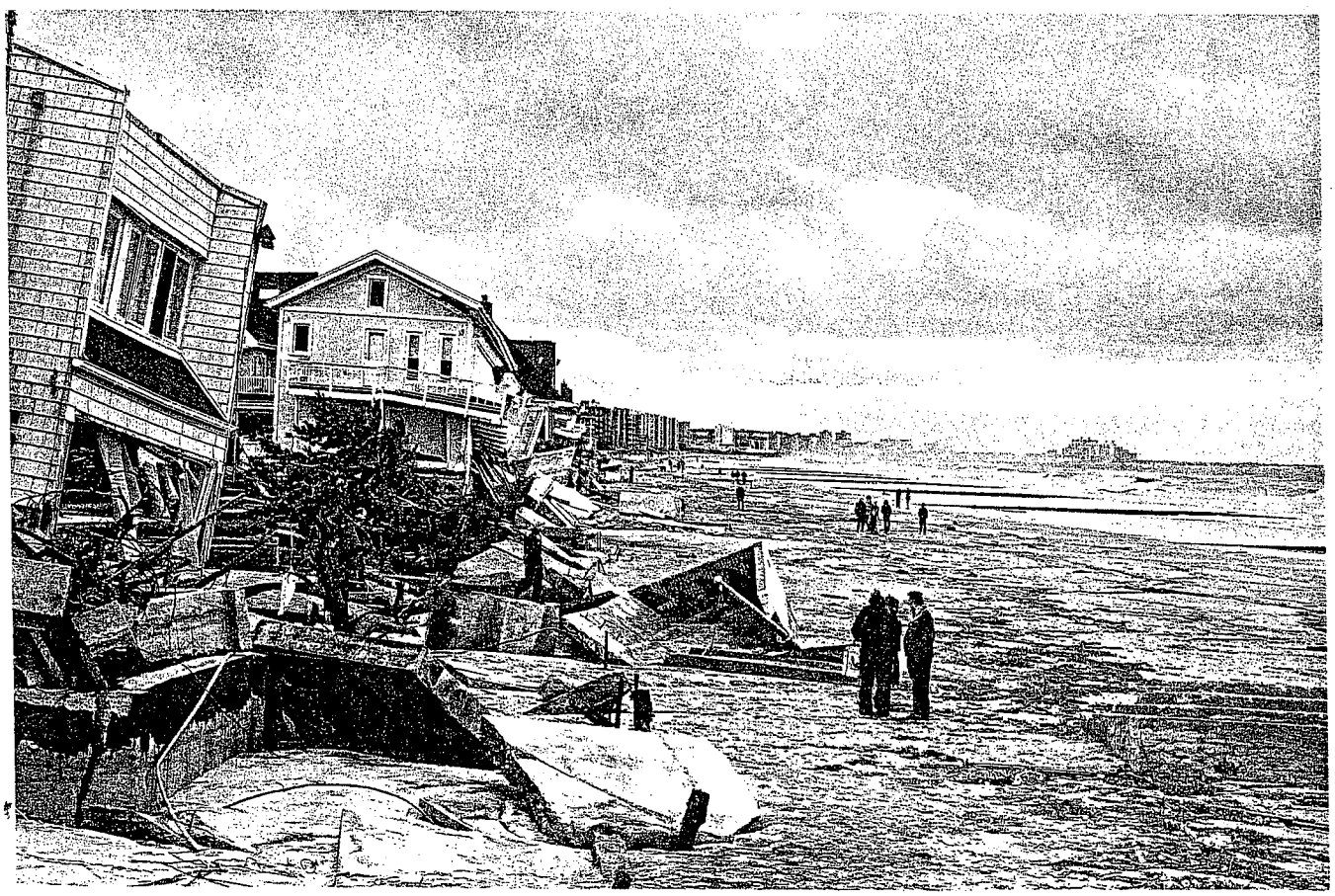
How can cities be "climate-proofed"?

BY ERIC KLINENBERG

In July, 1995, a scorching heat wave hit Chicago, killing seven hundred and thirty-nine people, roughly seven times as many as died in Superstorm Sandy. Soon after the heat abated, social scientists began to look for patterns behind the deaths. Some of the results were unsurprising: having a working air-conditioner reduced the risk of death by eighty per cent. But fascinating patterns did emerge. For the most part, the geography of heat-wave mortality was consistent with the city's geography of segregation and inequality: eight of the ten community areas with the highest death rates were virtually all African-American, with pockets of concentrated poverty and violent crime, places where old people were at risk of hunkering down at home and dying alone during the heat wave. At the same time, three of the ten neighborhoods with the *lowest* heat-wave death rates were also poor, violent, and predominantly African-American.

Englewood and Auburn Gresham, two adjacent neighborhoods on the hyper-segregated South Side of Chicago, were both ninety-nine per cent African-American, with similar proportions of elderly residents. Both had high rates of poverty, unemployment, and violent crime. Englewood proved to be one of the most perilous places during the disaster, with thirty-three deaths per hundred thousand residents. But Auburn Gresham's death rate was only three per hundred thousand, making it far safer than many of the most affluent neighborhoods on the North Side. Identifying the sources of such resilience is important, and not for merely academic reasons. The changing climate is likely to deliver more severe weather more often, and understanding why some neighborhoods fare better in a crisis than others that resemble them can help us prepare for the next disaster.

For the past decade and a half, governments around the world have been investing in elaborate plans to "climate-proof" their cities—protecting people, businesses, and critical infrastructure against weather-related calamities. Much of this work involves upgrading what engineers call "lifeline systems": the network infrastructure for power, transit, and communications, which is crucial in the immediate aftermath of a disaster. Some of the solutions are capital-intensive and high-tech; some are low- or no-tech approaches, such as organizing communities so that residents know which of their neighbors are vulnerable and how to assist them. The fundamental threat to the human species is, of course, our collective



The Rockaways, New York, after Hurricane Sandy. The city is beginning to plan for a future of extreme weather.

PHOTOGRAPH BY ADRIAN FUSSELL

inability to reduce our carbon emissions and slow the pace of climate change. Yet, even if we managed to stop increasing global carbon emissions tomorrow, we would probably experience several centuries of additional warming, rising sea levels, and more frequent dangerous weather events. If our cities are to survive, we have no choice but to adapt.

Klaus Jacob is a geophysicist at Columbia University whose 2009 report on climate risks to New York City contains eerily accurate predictions about what would happen to the city's infrastructure during a major storm surge. He works at the university's Lamont-Doherty Earth Observatory, a sprawling research campus for earth sciences perched above the Hudson River, on the Palisades. Its drab, boxy buildings make it look more like a military base than like a collegiate Arcadia. Jacob's office has the familiar academic freight of books, journals, and papers, but there's also a Day-Glo hard hat that has had some use over the years. When I asked him how he got interested in urban security, he told me about his childhood. "I was born in Stuttgart in 1936, and when the war started my parents moved us to a small village in Bavaria, because they knew we would be safer there," he said. "The family that moved into our home was killed two years later. The building was bombed." Jacob has a thick silver beard and pale-blue eyes, although his foreboding manner makes the effect less Kris Kringle than Old Testament prophet. He gave me an intent look. "I grew up in a war environment. And what I learned is that you can plan your fate, at least to some degree, if you assess your risks and do something about it."

Jacob's early research, which was funded by the United States Air Force, focussed on underground nuclear explosions, and he later studied how structures such as bridges and high-rise buildings could survive seismic shocks. In the nineteen-nineties, Jacob was asked to help New York City evaluate its capacity to withstand storms, and since then he has conducted similar studies for New York State and the M.T.A. His findings were sobering. "Much of the subway system is below sea level already," Jacob explained. During Sandy, several stations and lines filled up like bathtubs. Elevating and redesigning access points and the ventilation system would be an immense undertaking. "It will probably cost billions, maybe tens of billions, to protect it."

Jacob's computer screen displayed two maps of New York City neighborhoods, one color-coded by elevation and the other by population growth since 2000. "Look at the blue zones, which show where we've been developing real estate, and the pink ones, which show where the population is dropping," Jacob said. Downtown neighborhoods on the Hudson—Battery Park, Tribeca, the West Village, West Chelsea, and Hell's Kitchen—were solidly blue; neighborhoods uptown, on higher ground, were pink. "Think about all the projects we conceived more than a decade ago, before we knew about rising sea levels, in the name of waterfront revitalization," he went on. "They've been quite successful, but they've also placed a lot of people at risk."

Genuine adaptation, Jacob believes, means preparing for the inevitable deluge. "The ocean is going to reclaim what we took from it," he said. He thinks that New York can learn from Rotterdam, which has a long history of flooding. After enduring a devastating storm surge in 1953, Rotterdam began building a series of dams, barriers, and seawalls as part of a national project called Delta Works, and five years ago the Dutch government provided funds for an upgrade, the Rotterdam Climate Proof Program. Arnoud Molenaar, who manages it, says his team realized that they could convert the water that comes into the city from the skies and the sea into "blue gold." "Before, we saw the water as a problem," Molenaar told me. "In the Netherlands, we focussed on how to prevent it from coming in. New York City focussed on evacuation, how to get people out of the way. The most interesting thing is figuring out what's between these approaches: what to do with the water once it's there."

In 2005, Rotterdam hosted the Second International Architecture Biennale. The theme was "The Flood." Designers from around the world presented plans for how cities could cope with water in the future, and when the exhibition ended Molenaar's team set out to implement those that would have immediate practical value. Rotterdam is now experimenting with an architecture of accommodation: it has a floating pavilion in the city center, made of three silver half spheres with an exhibition space that's equivalent to four tennis courts; a water plaza that serves as a playground most of the year but is converted into a water-storage facility on days of heavy rainfall; a floodable terrace and sculpture garden along the city's canal; and buildings whose façades, garages, and ground-level spaces have been engineered to be waterproof.

Smart designs have improved other parts of the Netherlands' critical infrastructure. Its communications network features the fastest Internet speed in Europe, and, with I.B.M., it has built a system for water and energy management. It also has a resilient power grid, designed to withstand strong winds and heavy rain. In the United States, most distribution lines are elevated on wooden poles and exposed to falling tree branches; in the Netherlands, the lines are primarily underground and encased in water-resistant pipes. The Dutch grid is circular, rather than being a system of hub and spokes, so that, if a line goes out in one direction, operators can restore power by bringing it in from another source. And it's interconnected to the grids in neighboring countries, which gives the system additional capacity when there are local problems. This network architecture is more resilient in ordinary times, too. In Holland, the average duration of total annual power outages is twenty-three minutes, compared with two hundred and fourteen minutes in New Jersey, Pennsylvania, and New York—not including outages from disasters.

After Sandy, there was a five-day blackout in lower Manhattan, because the walls protecting Con Ed's substation along the East River, at twelve and a half feet above the ground, were eighteen inches too low to stop the storm surge and prevent the consequent equipment explosions. When I asked Jacob about this, he threw up his hands in exasperation. "Just put it on a high platform and use more underwater cable," he said. "We've had it available for a long time now. These are just moderate investments, in the millions of dollars. It's a small price to pay for more resilience."

The island nation of Singapore—where 5.2 million people are packed into seven hundred and ten square kilometres of land, much of which is perilously close to sea level—offers other lessons. Singapore began adapting to

dangerous weather thirty years ago, after a series of heavy rains during monsoon seasons caused repeated flooding in the low-lying city center. The country has always had a difficult relationship with water. Its geography makes it vulnerable to heavy seasonal rains and frequent flooding but there is never a sufficient supply of usable water, and in recent years Singapore's dependency on Malaysian water sources has led to political conflicts. Climate change, with its rising sea levels and increase in heavy rains, threatens the city-state's stability. But Singapore's government also sees this as an opportunity.

The Marina Barrage and Reservoir, which opened in 2008, is at the heart of Singapore's two-billion-dollar campaign to improve drainage infrastructure, reduce the size of flood-prone areas, and enhance the quality of city life. It has nine operable crest gates, a series of enormous pumps, and a ten-thousand-hectare catchment area that is roughly one-seventh the size of the country. The system not only protects low-lying urban neighborhoods from flooding during heavy rains; it also eliminates the tidal influence of the surrounding seawater, creating a rain-fed supply of freshwater that currently meets ten per cent of Singapore's demand. Moreover, by stabilizing water levels in the Marina basin the barriers have produced better conditions for water sports. The Marina's public areas, which include a sculpture garden, a water-play space, a green roof with dramatic skyline vistas, and the Sustainable Singapore Gallery, bolster the city's tourist economy as well.

The Marina is just one of Singapore's adaptation projects. The Mass Rapid Transit system has elevated the access points for the underground rail system to at least a metre above the highest recorded flood levels. To minimize damage, the Public Utility Board has improved its drainage systems. In the nineteen-seventies, thirty-two hundred hectares of land were flood-prone; today, only forty-nine hectares are. Singapore is further reducing its dependence on imported water by building new facilities for desalinating seawater, and developing technology for using reclaimed and treated wastewater in industrial settings. To reduce its energy consumption, the Building and Construction Authority requires that all new structures be insulated with materials designed to retain cool temperatures. Today, Singapore is better prepared not only for extreme weather but also for meeting future demands for power and water as its population grows.

Jacob doesn't think Rotterdam's or Singapore's arrangements can simply be replicated elsewhere, but he's impressed by their ambition and foresight. After Sandy, New York paid the price for its lack of preparation. In recent decades, American utility companies have spent relatively little on research and development. One industry report estimates that, in 2009, research-and-development investments made by all U.S. electrical-power utilities amounted to at most $700 million, compared with $6.3 billion by I.B.M. and $9.1 billion by Pfizer. In 2009, however, the Department of Energy issued $3.4 billion in stimulus grants to a hundred smart-grid projects across the United States, including many in areas that are prone to heat waves and hurricanes. The previous year, Hurricane Ike had knocked out power to two million customers in Houston, and full restoration took nearly a month. When the city received $200 million in federal funds to install smart-grid technology, it quickly put crews to work. Nearly all Houston households have been upgraded to the new network, one that should be more reliable when the next storm arrives.

Smart grids are in the early stages, but already they have several advantages over the old power systems. Digital meters, which are installed in households and at key transmission points, automatically generate real-time information about both consumers and suppliers, allowing utility providers to detect failures immediately, and sometimes also to identify the cause. This means that, after an outage, operators don't need to wait for calls from angry customers or field reports from crews. Moreover, smart grids are flexible, capable of being fed by disparate sources of energy, including systems powered by the sun and the wind. When the energy industry develops better technologies for storing power from these renewable resources, the new networks should be capable of integrating them.

Reëngineered grids will ultimately offer other benefits. "The situational awareness of the system might allow operators to reconfigure the system, either before or after the event, to maintain service," Leonardo Dueñas-Osorio, an engineering professor at Rice University who is developing resilience metrics for critical infrastructure systems, told me. "As a hurricane approaches, operators could 'island' areas that look like they will get the most damage. This breaks the system into small clusters and prevents cascading failures. It gives the operators more control, more capacity to keep the power going or get it back." Smart meters also enable consumers to go online anytime to learn when and how they use energy and how much they're spending. Already there's evidence that customers with this information are adjusting their behavior accordingly: easing off on air-conditioning, drying their clothes at night. Creating a smarter, more resilient grid for New York will be expensive, but not as expensive as a future filled with recurring outages during ordinary times and long-lasting failures when the weather turns menacing.

The communications system, too, is vulnerable to weather extremes; America's mobile-phone networks have always been less reliable than those in Europe, and regularly fail in catastrophes. During Sandy, emergency workers in New York and New Jersey were unable to communicate with colleagues who came from other states, because there's no nationwide network for first responders, and those from outside the region depended on cellular networks that were down. "Good public policies could potentially make these new networks much more resilient," Harold Feld, the senior vice-president of the digital-rights advocacy group Public Knowledge, says. The networks he envisages are flexible and have redundancies: "They can back each other up." Smart phones give the networks additional capacities for emergency communications, such as reverse-911 messaging that can be sent from government agencies to all customers in Zip Codes where dangerous weather is approaching, with geographically specific instructions on whether to evacuate or how to stay safe.

Unfortunately, the cellular industry has resisted efforts to regulate it, as the old telephone network is regulated, and there are no federal laws establishing minimum requirements for backup power during emergencies, no standards for how and when providers will share networks or drop roaming charges to give more people access to information, and

no rules for reporting what caused extended outages. "We have a public interest in building robust networks," Feld says. "And by now it's clear that we're not going to get them by letting industry regulate itself."

New York City will inevitably explore ways to reduce flooding. There are relatively inexpensive measures, such as restoring wetlands and planting oyster beds, and then there are more ambitious, capital-intensive approaches: engineers at the Dutch firm Arcadis have designed a $6.5-billion barrier that would go just north of the Verrazano-Narrows Bridge. Others have proposed a five-mile gate that would stretch from Sandy Hook, New Jersey, to Rockaway, New York. Malcolm Bowman, who runs the Storm Surge Research Group at SUNY Stony Brook, is among the leading advocates for such a barrier. "We can't just sit around waiting for the next catastrophe," he argues. "The time is now, and it's really just a matter of political will."

But there are debates about the long-term efficacy of these barriers. "Barriers are at best an intermediate solution," Jacob told me in his office. "They will require at least twenty years to build, because we'd need environmental-impact reports, and buy-in from the federal government, the state governments of New York, New Jersey, and Connecticut, and probably also about three hundred municipalities. If all that happens, we'd get protection for perhaps a few decades. Walls will keep out storm surges, but not the rising ocean, and they could cause a sense of false security that prevents us from finding real solutions."

Jacob's office lacks the high-powered computing equipment that one finds in the labs where engineers are designing sophisticated models for sea barriers. "I'm a conceptual thinker," Jacob told me. "I do the modelling in my head. And if we spend all our resources on expensive safety systems that are not sustainable we're not going to solve the problem. Sometimes engineers don't see things holistically. Earth science helps us see the bigger picture." Eventually, Jacob believes, the city will need to make a "managed retreat" to higher ground. "We have a lot of high areas that we're not using, or that we've used for cemeteries, in Queens. I think we need to switch the living and dead, and I think the dead would understand."

He turned again to his monitor. "Look at the map," he said, tracing the coastline in Brooklyn, Queens, and Staten Island, then running his fingers along the Hudson and the East River. "This is where the rising water will hit."

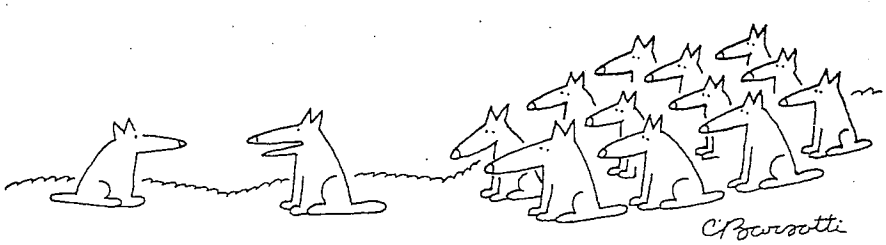
Still, a strategy of resilience will involve more than changes to our physical infrastructure. Increasingly, governments and disaster planners are recognizing the importance of social infrastructure: the people, places, and institutions that foster cohesion and support. "There's a lot of social-science research showing how much better people do in disasters, how much longer they live, when they have good social networks and connections," says Nicole Lurie, a former professor of health policy at RAND's graduate school and at the University of Minnesota, who has been President Obama's assistant secretary for preparedness and response since 2009. "And we've had a pretty big evolution in our thinking, so promoting community resilience is now front and center in our approach."

The Chicago heat wave proved to be a case study in this respect. Researchers who sifted through the data (I was among them) noticed that women fared far better than men, because they have stronger ties to friends and family and are less prone to isolation. Latinos, who had high levels of poverty, had an easier time than other ethnic groups in Chicago, simply because in Chicago they tend to live in crowded apartments and densely packed neighborhoods, places where dying alone is nearly impossible.

The key difference between neighborhoods like Auburn Gresham and others that are demographically similar turned out to be the sidewalks, stores, restaurants, and community organizations that bring people into contact with friends and neighbors. The people of Englewood were vulnerable not just because they were black and poor but also because their community had been abandoned. Between 1960 and 1990, Englewood lost fifty per cent of its residents and most of its commercial outlets, as well as its social cohesion. "We used to be much closer, more tight-knit," says Hal Baskin, who has lived in Englewood for fifty-two years and currently leads a campaign against neighborhood violence. "Now we don't know who lives across the street or around the corner. And old folks are apprehensive about leaving their homes." Auburn Gresham, by contrast, experienced no population loss during that period. In 1995, residents walked to diners and grocery stores. They knew their neighbors. They participated in block clubs and church groups. "During the heat wave, we were doing wellness checks, asking neighbors to knock on each other's doors," Betty Swanson, who has lived in Auburn Gresham for nearly fifty years, says. "The presidents of our block clubs usually know who's alone, who's aging, who's sick. It's what we always do when it's very hot or very cold here."

Robert J. Sampson, a sociologist at Harvard University, has been measuring the strength of social ties, mutual assistance, and nonprofit organizations in Chicago communities for nearly two decades. He has found that the benefits of living in a neighborhood with a robust social infrastructure are significant during ordinary times as well as during disasters. In 1990, life expectancy in Auburn Gresham was five years higher than it was in Englewood. And, during the severe heat waves that are likely to hit Chicago and other cities in the near future, living in a neighborhood like Auburn Gresham is the rough equivalent of having a working air-conditioner in each room.

Since 1995, officials in Chicago have begun to take these factors into account. During times of intense heat, the city has urged the local media to advise neighbors, friends, and family to check in on one another. City agencies have maintained a



"We're a pack, not a cult."

database that lists the names, addresses, and phone numbers of old, chronically ill, and otherwise vulnerable people, and city workers call or visit to make sure they're safe. Churches and civic organizations have encouraged neighbors to look out for one another, as have family and friends. In Englewood, meanwhile, residents and community organizations have invented their own version of the Rotterdam strategy, turning their main problem, abandonment, into an advantage. Their goal is to transform Englewood into a hub of urban farming, with gardens that create stronger community ties as well as fresh produce and shade.

Englewood, as it happens, is just a few miles from the neighborhoods where Barack Obama worked as a community organizer during the late nineteen-eighties, learning first hand why social ties matter. Obama must have been thinking of places like Englewood when, as a U.S. senator in 2005, he connected the effects of Hurricane Katrina to the slow-motion disaster that New Orleans's vulnerable neighborhoods endured every day. "I hope we realize that the people of New Orleans weren't just abandoned during the hurricane," he said. "They were abandoned long ago." Katrina, Obama continued, should "awaken us to the great divide that continues to fester in our midst" and inspire us to "prevent such a failure from ever occurring again."

Obama was one of many members of Congress who believed that Katrina exposed the shortcomings of a national-security strategy that marginalized non-terrorist threats. The following year, Congress passed the Post-Katrina Emergency Management Reform Act, which expanded FEMA's authority, and the Pandemic and All Hazards Preparedness Act, which authorized new programs to improve public-health responses, ranging from risk communications to targeted support for vulnerable populations. During his first term, President Obama introduced a new National Health Security Strategy that emphasized preparedness and resilience, calling for the participation of the "whole community"—government agencies, civic organizations, corporations, and citizens—in all aspects of the security plan. "It was a pretty big evolution in our own thinking, to be able to put community resilience front and center," Nicole Lurie says.

Since March, 2011, when Obama issued a directive on national preparedness, FEMA has embraced a similar approach to community resilience. "Community-engagement" pilot programs funded by the Centers for Disease Control and Prevention have been launched in Los Angeles, Chicago, New York City, and Washington, D.C. "There's always been a big focus on classic infrastructure in mitigation," Alonzo Plough, the director of emergency preparedness and response for the County of Los Angeles, says. "But it's not just engineering that matters. It's social capital. And what this movement is bringing to the fore is that the social infrastructure matters, too."

Sandy revealed serious flaws in all forms of infrastructure in New York and New Jersey. But it also turned up surprising reserves of strength. When I visited Rockaway Beach in mid-November, residents complained about the slow pace of recovery. The power was out. The gas was off. Phone service was spotty. Trains weren't running. Sewage water from the flooding covered the streets. Still, there were some bright spots. The Rockaway Beach Surf Club, which opened in March, in a converted auto-repair shop beneath the El on Beach Eighty-seventh Street, transformed itself into a temporary relief agency when two of its founders returned there after the storm, posted Facebook updates inviting friends to join them, and watched more than five thousand volunteers come to help. It became the main community organization, providing food, cleaning supplies, camaraderie, and manual labor for nearby residents. The surf club's neighbors, including blue-collar families and poor African-Americans who, months before, had worried about how the club would fit into the community, joined in and benefitted from the organization.

Ofelia Mangen, a thirty-year-old who lives with her younger brother in a row house on Beach Ninety-second Street, joined the surf club last summer and spent many nights there volunteering with neighbors and friends. "I brought flowers, bartended, worked the door—whatever was needed," she told me, as we walked down Rockaway Freeway on a mild day in mid-November, past sanitation trucks, police cars, and sidewalks cluttered with debris. "I've just kept doing whatever is needed since the storm hit. But now the needs have changed, and there's obviously a lot more of them." Two weeks had passed since the superstorm, and residents had no power, gas, heat, or hot water for bathing. Stores, restaurants, pharmacies, and gas stations were closed. Trains were inoperable.

Mangen, a graduate student in educational design at New York University, has a steady disposition. She's slim but sturdy, with curly brown hair, thick glasses,

THE PEARL

She lost an earring—who knew
our bed could be so vast?

She combed the sheets:
blue thread tangled in itself,
nibbled transparent moth wing,
two deeply veined maple keys.

She found Bushwick, dawn,
marriage, work, middle age.

What makes her so stubborn,
raking each seam gingerly,
unable to resist the sheen
of a hook with a missing bead?

—D. Nurkse

and a strong, deliberate voice. She had a plastic crate for carrying things and was dressed for manual labor: black ski cap, black puffer jacket, black arm warmers, cargo pants, and hiking boots. "The sidewalks are still coated with sewage, and there's dangerous shit everywhere," she warned.

We began at her place, which, like all the houses in the area, sustained major flood damage. (The garage door showed a watermark about four feet above ground.) Several boxes of family photographs and a recently restored 1965 Ford Mustang belonging to the homeowner's son were among the casualties. We took supplies from Manhattan to a café where the staff was feeding relief workers, and then walked to the compost garden that Mangen helps run and inspected the soil, which had been drenched by contaminated floodwater. She instructed two arborists, who had arrived from Tennessee the night before, on how to prepare a fallen tree so that neighbors could use it as firewood, and offered respirator masks and large garbage bags to a worker from Illinois who was removing water-damaged drywall next door. Then we headed back to her street. A fallen tree rested ominously on the roof of a two-story apartment building on the corner.

Mangen spotted Junior, a neighbor who works as a contractor, parking his van across the street from us, and she led us to the apartment building so that we could see if anyone was there. "Hello," she shouted, and then banged on the door a few times. "Anybody home?" A young brown-skinned woman peeked out from the second-floor window, beneath the fallen tree. "Are you O.K. up there?" Mangen asked. "Do you need anything?"

"Juice," she answered. "For the baby."

We returned to the surf club, where residents, many with shopping carts, lined the sidewalk, putting in requests for food and supplies and waiting while volunteers fetched them. Mangen introduced me to Brandon d'Leo, a sculptor, and Bradach Walsh, a firefighter, who were directing the club's relief efforts, and they enlisted me in the search for volunteers to meet their neighbors' most pressing needs. "You're from a school," d'Leo noted. "Do you know anyone who teaches plumbers or electricians? We can't get power restored in our homes until we've passed an inspection by someone with certification."

When Mangen returned to her neighbor's apartment to deliver the juice, the woman came down to greet us. She held an infant, and appeared to have a painful sore on her lip. "Can we get you anything else?" Mangen asked. The woman shook her head, but hesitantly. "Listen, there's food at the surf club down on Beach Eighty-seventh," Mangen told her. "It's just a few minutes from here. And there are places giving out medicine now, too." The woman smiled shyly, thanked her, and returned to her dark apartment. A few minutes later, walking back to her place, Mangen had a thought. She called the arborists from Tennessee and asked them if they could take on another job. Soon afterward, the tree resting on her neighbor's rooftop was removed.

Thousands of people whose homes were damaged by Sandy live in neighborhoods that lack strong support networks or community organizations capable of mounting a large relief effort. They tend to be poorer and less educated than typical New Yorkers, with weaker ties to their neighbors as well as to political power brokers. Since Sandy, Michael McDonald, who heads Global Health Initiatives, in Washington, D.C., and worked in Haiti after the 2010 earthquake, has been coördinating relief efforts by volunteer groups, government agencies, corporate consultants, health workers, and residents in vulnerable areas, particularly in the Rockaways. McDonald calls the network the New York Resilience System, and he's convinced that civil society will ultimately determine which people and places will withstand the emerging threats from climate change. In December, I watched him chair a meeting of network participants—they included representatives from New York Cares (the city's largest volunteer organization), the accounting and consulting firm PricewaterhouseCoopers, the New York City Department of Health, and the state Attorney General's Office. "What's actually happening on the ground is not under an incident command system," he told me. "It's the fragile, agile networks that make a difference in situations like these. It's the horizontal relationships like the ones we're building that create security on the ground, not the hierarchical institutions. We're here to unify the effort."

Whether they come from governments or from civil society, the best techniques for safeguarding cities don't just mitigate disaster damage; they also strengthen the networks that promote health and prosperity during ordinary times. Contrast this with our approach to homeland security since 9/11: the checkpoints, the bollards, the surveillance cameras, the no-entry zones. We do not know whether these devices have prevented an attack on an American city; but, as the sociologist Harvey Molotch argues in "Against Security," they have certainly made daily life less pleasant and efficient, imposing costs that are difficult to measure while yielding "almost nothing of value" in the normal course of things.

"We were making some progress on climate-change adaptation in the late nineteen-nineties," Klaus Jacob observed. "But September 11th set us back a decade on extreme-weather hazards, because we started focussing on a completely different set of threats." Effective climate-proofing demands more intelligent design. It should provide benefits not just when disaster strikes but day to day, like Singapore's Marina Barrage, which created new waterfront, parkland, and exhibition spaces, or like a smarter power grid, which helps reduce energy consumption in all weather. That's true of the low-tech and the no-tech measures. Auburn Gresham's advantages over Englewood aren't restricted to mortality rates during a heat wave.

It's a cause for regret that we're not responding to the challenges of climate change with the same resources we've devoted to the war on terror. As long as the threat from global warming seemed remote and abstract, it was easier to ignore. Now climate change is coming to mean something specific, and scary. "Even on a clear day a hundred years from now, the water will be where it is today under storm-surge conditions," Jacob said. More heat waves, wildfires, hurricanes, and floods are to be expected. We are entering an age of extremes. "We can't just rebuild after every disaster," Jacob continued. "We need to pro-build, with a future of climate change in mind." ♦

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THE AFTERMATH OF HURRICANE SANDY: A NEW PARADIGM FOR THE ELECTRIC POWER GRID

Paul J. Kaufman*

If ever there was a belief that the Northeast was immune from the havoc that natural disasters wreak on electrical infrastructure and the hardship that outages impose on people and businesses that rely on that infrastructure, that belief was shattered last week. Hurricane Sandy's waters flooded underground utility vaults, shut down generating plants and emergency generators and caused substations to flash in Manhattan. Sandy's winds shattered distribution systems in New Jersey and New York, causing outages for hundreds of thousands of residents. The numbers vary, but the day after the storm hit, about 1 million utility customers in New York City's five boroughs and suburbs were out of power. The number of New Jersey customers was about 2.7 million without power at the peak of the storm. The outages persisted, in pockets large and small, such that as of November 12, thousands were still without power. The U.S. Energy Department said more than 160,000 customers in 10 states still had no power on that day.

The storm has raised the following issues to consider when it comes to the grid:

First, are we in a "new reality", as suggested by the New York Times in a recent article? It seems like just yesterday that New York and New Jersey were recovering from Hurricane Irene. After Sandy left the metropolitan New York area last week, the Northeast found itself bracing for another storm, a "Nor'easter that people feared would bring snow and rain to the area ravaged by Sandy.

Second, is now the time to consider how we respond to the "new reality?" Since Sandy's landfall, utility line crews have focused their attention on restoring service as quickly as possble. Utility executives have been subjected to criticism for the extent and duration of the outages. If our "new reality" is stronger and more frequent storms, shouldn't we also focus on how to better prepare ourselves for the next storm? If we wait, and as the Times has suggested, "a no longer frazzled public may rebel if taxes and fees rise sharply to pay for better defenses," our nation will find itself with more catastrophic outages and more questions about our prudence for not responding to a hurricane in the East, flooding in the Midwest, an earthquake or another unforseen, but perhaps forseeable, natural disaster in a more systematic fashion.

Third, what should the systematic response to natural disasters look like? Last Sunday, the Times ran an article, "Protecting New York City, Before the Next Big Storm Hits," (November 4, 2012), which set out three different approaches designed to keep at bay the tidal flows and storm surges that caused so much damage. These approaches, to increase the number of salt-water marshes surrounding low-lying areas and change paving materials so that they absorb water, to construct a storm surge barrier across the Arthur Kill tidal straight that separates Staten Island from New Jersey, and add oyster beds to the waters surrounding Brooklyn neighborhoods, are in the planning and "idea" stages.

However, is lookng only to big projects, at the expense of quickly pursuing a number of smaller projects, prudent?

Shouldn't we look at smaller fixes that will either increase the survivability of critical infrastructure or decrease the repair time after a storm?

Big fixes are difficult often complex and almost always expensive. Consider the cost of adding marshes to lower Manhattan, an action that will likely require either the acquisition of otherwise buildable land or the reclamation of land from the harbor. Building a storm surge barrier across the Arthur Kill will be subject to extensive technical debate on a range of engineering and environmental questions. How will these projects be funded and, ultimately, who will pay their cost?

Big fixes generally require extensive public input, cross jurisdictional boundaries between counties, states, and between Federal and state governments. Admitedly, I am not an expert on New York and New Jersey political or agency boundaries, or the governance of those political entities, however, I expect that there isn't one agency or one governmental body that can decide the outcome and future of the fixes discussed above. Involving multiple jurisdictions, and multiple agencies, multiplies the time necessary for a decision and plan to implement the decision. Multiplying the time associated with completing a project rarely translates to a decrease in the overall cost of the project.

While I have nothing against big fixes, I am in favor of adopting quicker smaller "fixes" that will address at least a portion of the problems causing the outages and damage caused by Sandy in the New York metropolitan area. While we look at insulating cities in general from storm surges and tidal influence, let's take the small steps that can be implemented quickly.

So, in addition to considering higher and more seawall and complex storm barriers, let's increase the elevation of electrical transformers at substations, allow emergency generators and their fuel supply to locate in floors above the likely flood level, give greater support to tree trimming programs, and consider undergrounding distribution lines.

While we consider "waterproofing" our central station generating plants, let's consider how to distribute generation more widely through the use of renewable resources or distributed thermal generation. Let's implement smart grid solutions that will allow utilities to isolate smaller portions of their distribution systems and quickly identify where outages are occurring and why.

Admittedly, small projects are not without their hurdles. However, when it comes to improving our electrical infrastructure considerably fewer agencies, political instrumentalities, and technical complexity is involved. Further, certain of the small fixes suggested above also have the benefit of increasing the security of our infrastructure from terrorist attacks, not just from attacks by Mother Nature.

In addition, mechanisms already exist for the consideration and approval of utility improvements. Generally speaking state regulation allows for surcharges to recover the costs of restoring a distribution system and some states also allow utilities to create sinking funds that are funded by ratepayers and used for capital improvements.

This is not to say that these mechanisms are perfect. Generally they involve case-specific, rather than programmatic, regulatory review. Further, when a utility seeks to recover the costs of its actions in rates, the regulatory review process lends itself to 20-20 hindsight.

Consider undergrounding of utility distribution. Undergrounding is costly and the mechanisms for getting cost recovery for undergrounding generally involve review of a specific proposal for a specific geographic area. For example, under the California Public Utility Commission's Rule 20, before a utility can use ratepayer funds for undergrounding it must prove that the project a number of factors including, whether the project will "eliminate an unusually heavy concentration of overhead lines," and whether the project will "involve a street or road with a high volume of public traffic."

The cost of restoring a system is also generally considered on a case-by-case basis. Before the utility can include costs in its rates, utilities generally have to show that they acted prudently and that their actions did not contribute to the outages or the delay in restoring service. Did the utility cut back on its tree-trimming program? Did it cut back on other capital investments that would have avoided some portion of the impact? When a utility proposes undergrounding its distribution system, the cost of undergrounding is generally compared to the cost of an above-ground distribution system.

If our goal is to promote small fixes, rather than focus our energies and hopes on big fixes, then regulatory processes need to adjust to the new reality. We need a forum for proposing how utilities will increase survivability and decrease the length of outages. The capital investments necessary to implement utility plans should still be judged by regulators for their prudence and reasonableness, but the point of comparison should be the "new reality" and not the status quo ante. Hurricane Sandy has shown us that no single region of

our country is immune from catastrophe. As a nation, we will be judged by our response to Sandy and the paradigm shift it represents.

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